NANOENGINEERING

NanoEngineering emphasizes micro-nanoscale engineering courses necessary to work in areas such as semiconductor manufacturing, molecular electronics, integrated silicon photonics, nanomedicine, micro- and nano-electromechanical systems, thin film technologies, and other applications of nanotechnology. The engineering coursework is grounded in a strong foundation of mathematics and physics. This program uses multidisciplinary approaches in solving problems with a global understanding of engineering design, systems optimization, and fabrication techniques. Graduates will address the complex needs and challenges of cutting-edge nanotechnology using manufacturing, characterization, and analysis tools including those in a cleanroom environment. Rose-Hulman's NanoEngineering graduates are trained to take up any demanding jobs for the development of new technologies or to pursue graduate school for further studies in engineering or physics.

Mission

To provide a coherent foundation of physics and cutting-edge engineering that leads to a large variety of possibilities for its graduates. NanoEngineering graduates are trained in design, optimization, fabrication, and testing of semiconductor and nanoscale systems. Graduates are enabled to practice their dynamic and progressive engineering profession in emerging fields as responsible citizens of the global society.

Vision

To cultivate in students the responsibility, independence, and knowledge that allows them to be fully engaged engineers in all disciplines, to continuously improve their knowledge and skills, and to be engaged in the development process of emerging nanotechnologies and semiconductor manufacturing.

Requirements

Courses Taken in the Respective Departments

Subject	# Classes	Hours
Physics (PH)	11	44
Math (MA)	6	27
Chemistry (CHEM)	2	8
CSSE/ME	1	4
EM	2	4
RHIT 100	1	1
ES	1	4
HSSA	9	36
NanoEngineering (NE)	8	30
NanoEngineering Design (NE)	3	12
Electives (SEM, Eng. and Free)	6	24
Total	**50**	**194**

Summary of Graduation Requirements for Nanoengineering

1. All the courses listed above by the number.
2. The program must be approved by the NE advisor.
3. A list of the engineering electives is provided.
4. Free engineering electives are any courses in engineering.
5. SEM (Science, Engineering, Math) electives are courses that need to be taken at the 200 level (CHEM 115, ECE 180, and EM 121 are allowed) or above in biology, biomathematics, chemistry, computer science, engineering, mathematics or physics.
6. Unrestricted Free electives are any courses.

Classes by Subjects

Code	Title	Hours
Physics Coursework (8 classes)		32
Freshman Physics, Chemistry and Mathematics (11 classes)		47
Humanities, Social Science, and the Arts (Standard requirement - 9 classes)		36
EM, ES, ME, RHIT100 (5 classes)		13
NE Courses (8 classes)		30
NE Capstone Design (3 classes)		12
Approved Engineering Electives (2 classes)		8
Free Electives (8 credits Engineering, 4 unrestricted credits - 3 classes)		12
SEM Electives (1 class)		4
Total Hours		**194**

Foundation Physics Classes

Code	Title	Hours
PH 235	Many-Particle Physics	4
PH 255	Foundations of Modern Physics	4
PH 316	Electric & Magnetic Fields	4
PH 317	Electromagnetism	4
PH 325	Adv Physics Laboratory I	4
PH 327	Thermodynamics & Statistical Mechanics	4
PH 401	Introduction to Quantum Mechanics	4
PH 405	Semiconductor Materials & Applications	4

General Foundation Classes

Code	Title	Hours
PH 111	Physics I	4
PH 112	Physics II	4
PH 113	Physics III	4
MA 111	Calculus I	5
MA 112	Calculus II	5
MA 113	Calculus III	5
MA 221	Matrix Algebra & Differential Equations I	4
MA 221	Matrix Algebra & Differential Equations I	4
MA 223	Engineering Statistics	4
or MA 381	Introduction to Probability with Applications to Statistics	
CHEM 111	General Chemistry I	3
CHEM 113	General Chemistry II	3

Engineering Foundation

Code	Title	Hours
EM 104	Graphical Communications	2
NE 180	Engineering at the Nanoscale	2
NE 280	Introduction to Nanoengineering	4
NE 320	Fundamentals of Thin Films: Fabrication and Applications	4
NE 380	Nanotechnology, Entrepreneurship & Ethics	4
NE 395	Nanoscale Fabrication & Characterization Techniques	4
NE 406	Semiconductor Devices & Fabrication	4
NE 407	Nanoelectronic and Semiconductor Devices	4
NE 410	Introduction to MEMS: Fabrication & Applications	4
ES 213	Electrical Systems	3
ES 213L	Electrical Systems Lab	1
ME 123	Computer Programming	4
Engineering Elective		16

Design Sequence

Code	Title	Hours
EM 103	Introduction to Design	2
NE 415	NanoEngineering Design I	4
NE 416	NanoEngineering Design II	4
NE 417	NanoEngineering Design III	4

Approved Intermediate Engineering Electives (4 credit hours required)

Code	Title	Hours
ECE 205	Circuits and Systems	4
ES 201	Conservation & Accounting Principles	4
ES 312	Fluid Systems	4
EM 204	Statics & Mechanics of Materials II	4
OE 280	Geometrical Optics	4
NE 290	Directed Research	1-4
CHE 315	Materials Science and Engineering	4
ME 328	Materials Engineering	4
NE 490	Directed Research	1-4
Additional electives as approved by the NE Curriculum Committee		

Approved Advanced Engineering Electives (4 credits required)

Code	Title	Hours
OE 360	Optical Materials	4
OE 393	Fiber Optics and Applications	4
OE 437	Introduction to Image Processing	4
OE 450	Laser Systems & Applications	4
OE 460	Silicon Photonic Devices and Applications	4
OE 495	Optical Metrology	4
NE 330	Material Failure	4
NE 408	Microsensors and Actuators	4
NE 450	Nanomedicine	4
NE 470	Special Topics in NanoEngineering	2-4
NE 490	Directed Research	1-4
MDS 439	Advanced topics in MEMS	4
CHE 315	Materials Science and Engineering	4
ME 417	Advanced Materials Engineering	4
ME 422	Finite Elements for Engineering Applications	4
EM 403	Advanced Mechanics of Materials	4
ECE 351	Analog Electronics	4
ECE 250	Electronic Device Modeling	4
ECE 351	Analog Electronics	4
Additional electives as approved by the NE curriculum committee		

Plan of Study

Below is a sample plan of study that illustrates one way to achieve the program requirements. Any given student's plan of study may differ based on a variety of factors (e.g., advanced credit, placement exams, adding a minor). Enrolled students will work with their academic advisor; utilize the degree audit/planner to create a specific plan of study.

Course	Title	Hours
Freshman		
Fall		
PH 111	Physics I	4
MA 111	Calculus I	5
RHIT 100	Foundations for Rose-Hulman Success	1
EM 104	Graphical Communications	2
CHEM 111	General Chemistry I	3
CHEM 111L	General Chemistry I Lab	1
	Hours	**16**
Winter		
PH 112	Physics II	4
MA 112	Calculus II	5
HUM H190	First-Year Writing Seminar	4
CHEM 113	General Chemistry II	3
CHEM 113L	General Chemistry II Laboratory	1
	Hours	**17**
Spring		
PH 113	Physics III	4
MA 113	Calculus III	5
ME 123 or CSSE 120	Computer Programming or Introduction to Software Development	4
NE 180	Engineering at the Nanoscale [1]	2
EM 103	Introduction to Design	2
	Hours	**17**
Sophomore		
Fall		
ES 213	Electrical Systems	3
ES 213L	Electrical Systems Lab	1
PH 235	Many-Particle Physics	4
Science, Engineering or Math Elective		4
200-Level Engineering Elective		4
	Hours	**16**
Winter		
NE 280	Introduction to Nanoengineering	4
PH 255	Foundations of Modern Physics	4
MA 221	Matrix Algebra & Differential Equations I	4
ECON S151 or ECON S152	Introduction to Microeconomics or Introduction to Macroeconomics	4
	Hours	**16**
Spring		
NE 380	Nanotechnology, Entrepreneurship & Ethics	4
PH 325	Adv Physics Laboratory I	4

MA 222	Matrix Algebra & Differential Equations II	4
Engineering Elective		4
	Hours	**16**
Junior		
Fall		
PH 316	Electric & Magnetic Fields	4
NE 320	Fundamentals of Thin Films: Fabrication and Applications	4
PH 405	Semiconductor Materials & Applications	4
HSSA Elective		4
	Hours	**16**
Winter		
MA 381 or MA 223	Introduction to Probability with Applications to Statistics or Engineering Statistics	4
PH 317	Electromagnetism	4
ENGL H290	Technical & Professional Communication	4
NE 406	Semiconductor Devices & Fabrication	4
	Hours	**16**
Spring		
PH 327	Thermodynamics & Statistical Mechanics	4
NE 415	NanoEngineering Design I	4
MDS 437	Introduction to MEMs: Fabrication & Applications	4
HSSA Elective		4
	Hours	**16**
Senior		
Fall		
NE 416	NanoEngineering Design II	4
NE 407	Nanoelectronic and Semiconductor Devices	4
NE 320	Fundamentals of Thin Films: Fabrication and Applications	4
HSSA Elective		4
	Hours	**16**
Winter		
NE 417	NanoEngineering Design III	4
300/400-Level Engineering Elective		4
HSSA Elective		4
PH 401	Introduction to Quantum Mechanics	4
	Hours	**16**
Spring		
HSSA Elective		4
HSSA Elective		4
Engineering Elective		4
Free Elective		4
	Hours	**16**
	Total Hours	**194**

[1] If students miss NE 180 Engineering at the Nanoscale in the freshmen or sophomore year, this requirement must be replaced with a 300 or 400-level NE course of at least 2 credits.

Notes:

NE course descriptions are listed under the Physics and Optical Engineering Department.

Program Objectives
NE Program Educational Objectives

Based on our mission and the needs of our constituents, our graduates will:

- solve complex problems, create new knowledge, and incorporate innovative solutions.
- be a good citizen of the world, participate in solving major world problems such as climate change and poverty, and develop products and policies that are ethically, socially, and economically responsible.
- adopt and learn new skills, engage in lifelong learning, continue developing their knowledge, and teach others the benefits and limitations of their field.
- explain complex problems to a wide audience of different backgrounds and bridge the gap between different fields of study.
- collaborate, work well in a diverse and interdisciplinary team, and build relationships.

Learning Outcomes
NE Student Learning Outcomes

- Outcome 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- Outcome 2: an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- Outcome 3: an ability to communicate effectively with a range of audiences
- Outcome 4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- Outcome 5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Outcome 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Outcome 7: an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

The nanoengineering program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org, under the commission's General Criteria with no applicable program criteria.