

Undergraduate Designated Minors in Carnegie Institute of Technology

Undergraduate students in the Carnegie Institute of Technology can elect to complete an interdisciplinary Designated Minor in addition to their regular majors for B.S. degrees. Designated minors have been added to the curriculum of the Carnegie Institute of Technology to promote flexibility and diversity among the college's engineering students. Independent of a student's major, he or she is able to pursue a selected designated minor from the following list:

- * Automation and Control
- * Biomedical Engineering
- * Colloids, Polymers and Surfaces Technology
- * Data Storage Systems Technology
- * Electronic Materials
- * Engineering Design
- * Environmental Engineering
- * International Engineering
- * Manufacturing Engineering
- * Materials Science and Engineering
- * Mechanical Behavior of Materials
- * Robotics (previously described)

An engineering student may elect to complete a CIT designated minor. Generally, the student takes all the required courses in an engineering major but uses electives to take courses needed to fulfill the requirements of the designated minor. Upon completion of the requirements of a CIT designated minor and the engineering degree, the minor is a formally recognized on the student's transcript.

Each of the CIT designated minors is administered by a Program Committee consisting of faculty from all major engineering departments who serve as faculty advisors. Each Program Committee certifies the completion of requirements of the designated minor. But the student's major department is responsible for approving the degree with a designated minor after reviewing a student's entire academic record. Any substitution or departure from the published curriculum should be avoided. For example, non-technical courses may not be substituted for required technical courses or electives. Equivalent technical electives offered by a designated minor as substitutions for required courses in a major must be approved by the Head of the student's major department.

Although a student generally can complete a designated minor without increasing the number of required units for graduation, early planning in electing a designated minor is important. A student also may find that some minors are more compatible than others with his/her major because of different relations between various major and minor requirements. The requirements for these CIT designated minors are listed below.

Automation and Control Engineering Designated Minor

Bruce Krogh, Director Office: Porter Hall B22

The objective of the Designated Minor in Automation and Control Engineering is to expose CIT students to the breadth of knowledge required by the modern practice of control and automation. With this objective in mind, the requirements include not only two courses in control system analysis and design, but also courses on real-time computation, software engineering, hardware implementation, and applications. The minor is expected to attract primarily students from Chemical Engineering, Electrical and Computer Engineering, and Mechanical Engineering. The main interdisciplinary component of the minor is between engineering and computer science, although many opportunities exist for creating a program across several CIT departments.

Faculty Advisors

Electrical & Computer Engineering - Pradeep K. Khosla
 Civil & Environmental Engineering - James Garrett
 Mechanical Engineering - William Messner
 Chemical Engineering - Erik Ydstie
 Course Requirements for Automation and Control

Engineering Minor

The minor requires a minimum of six courses as described below:

Note: The course lists below are not necessarily current or complete. Appropriate courses not listed below may be counted toward the requirements for the minor upon approval by one of the departmental faculty advisors. Students interested in the Automation and Control Engineering Designated Minor are encouraged to look for applicable courses each semester in CIT, CS, and Robotics.

One basic control course:

06-362	Chemical Engineering Process Control
18-470	Fundamentals of Control
24-451	Feedback Control Systems

One course on control system analysis and design:

06-708	Advanced Process Dynamics and Control
18-771	Linear Systems

One course on computing and software:

15-211	Fundamental Data Structures & Algorithms
15-212	Principles of Programming
12-741	Advanced Programming Concepts in CAE
18-549	Embedded Systems Design
18-649	Embedded Systems

One course on hardware implementation:

06-311	Unit Operations Laboratory
18-474	Embedded Control Systems
18-578	Mechatronic Design

One course on applications:

06-606	Computational Methods for Large Scale Process Design and Analysis
12-615	Traffic Flow Theory and Operations
16-311	Introduction to Robotics
16-743	Robot Control
16-761	Introduction to Mobile Robots
24-356	Engineering Vibrations
24-351	Engineering Dynamics
xx-xxx	12 independent project units

One elective course:

xx-xxx	Any course in the list above excluding the basic control course category
12-748	Design of CAE Systems
15-381	Artificial Intelligence: Representation and Problem Solving
15-385	Computer Vision
15-413	Software Engineering
15-498	Introduction to Real-Time Software
18-348	Embedded Systems Engineering
18-349	Embedded Realtime Systems
18-491	Digital Signal Processing I
18-771	Linear Systems
18-777	Complex Large-Scale Dynamic Systems
24-341	Manufacturing Sciences

Biomedical Engineering Designated Minor

Todd Przybycien, Director
 Office: Doherty Hall A-220

Biomedical Engineering (BME) at Carnegie Mellon is designed to train engineering students to apply the techniques of mathematics and science to the solution of problems in medicine and biology. Emphasis is placed on describing biological organisms as engineering systems and on applying engineering technology to clinical and laboratory situations. Students graduate with an accredited engineering degree in a traditional engineering major with a minor in biomedical engineering.

What Can a Student Do After Completing the Bachelor's Degree?

Upon completing the Biomedical Engineering Minor, the student may elect to continue graduate studies in Bioengineering at either the Masters or Ph.D. levels, or continue in medical school for the

MD degree. Many of the courses in the BME minor will assist in preparing you for medical school. Students who remain in the field of biomedical engineering are involved with developing and improving medical instruments and devices, automating medical procedures using computers, characterizing the operation of physiological systems, designing artificial organs and altering microbes and mammalian cells so that useful drugs and chemicals can be produced.

The graduate may secure employment in areas of bioinstrumentation, biocompatibility, optics, pharmacology, or the environment.

Faculty Advisors

The Biomedical Engineering Program provides a focus for faculty from diverse engineering backgrounds. There is also extensive collaboration with investigators in the local health care community. Clinical collaborations are seen as vehicles to keep research responsive to clinical needs, enhance the exposure of our students to a variety of clinical environments, and assist the clinical community in solving engineering problems.

One faculty member will be assigned the advisor to each engineering department. Hilda Diamond in Doherty Hall 2100 will also help with the bookkeeping aspects of advising and attention to details (student course requirements, scheduling of BME courses, working with departments to avoid conflict). Coordination with advising in the other major of the student is essential. Students will need to have traditional engineering advisor to approve final schedules. Following are advisors in departments:

Chemical Engineering: Dr. Todd Przybycien, Dr. Michael Domach, Dr. Lynn Walker
Civil & Environmental Engineering: Dr. Jean VanBriesen
Electrical & Computer Engineering: Dr. Richard Stern, Dr. Chuck Neuman
Materials Science & Engineering: Dr. Lisa Porter; Dr. Henry Piehler
Mechanical Engineering: Dr. Cristina Amon, Dr. Jon Cagan

A summer opportunities program is available to students pursuing the minor at the completion of their sophomore year.

Course Requirements for Biomedical Engineering Designated Minor

General Requirements (five courses, 48-51 units)

- Introduction to BME (42-101) 12 units
- Modern Biology (03-121) or Biochemistry (03-231 or 232) 9 units
- BME Elective or Domain 9-12 units
- BME Elective or Domain 9-12 units
- BME Elective or Domain 9-12 units

BME Domain Courses

03-121	Modern Biology
03-240	Cell Biology
03-310	Introduction to Computational Biology
03-311	Computational Molecular Biology
03-330	Genetics
03-343	Experimental Generics and Molecular Biology
03-344	Experimental Biochemistry
03-345	Experimental Cell and Developmental Biology
03-350	Developmental Biology
03-438	Physical Biochemistry
03-439	Introduction to Biophysics
03-441	Molecular Biology of Prokaryotes
03-442	Molecular Biology of Eukaryotes
03-510	Computational Biology
03-533	NMR in Biomedical Sciences
03-534	Bio Imaging Fluorescence Spectroscopy
09-245	Physical Chemistry II
15-211	Fundamental Structures of Computer Science I
42-301	Physiology
42-377	Rehabilitation Engineering
42-501	Special Topics: Biomaterials I & II
42-560	Research Project (at CMU or UPMC)
42-604	Biological Transport
42-621/06-621	Biotechnology & Environmental Processes
42-622/06-622	Bio Process Design
42-644	Medical Devices
42-651/12-651	Air Quality Engineering
42-652	Introduction to Biomechanics
42-723/12-723	Biological Processes in Environmental Systems

BME Electives

06-607	Phys Chem of Colloids and Surfaces
06-609/09-509	Physical Chemistry of Macromole 06-313
06-313	Exp Colloid Science
06-314	Exp Polymer Science

06-426	Experimental Colloid Surface Science
06-466	Experimental Polymer Science
18-3XX*	
19-607	Special Topics in Biotechnology
24-354	General Robotics
24-779	Human Systems and Control
27-432	Electrical, Magnetic, and Optical Properties of Materials
27-441	Deformation and Fracture of Materials
36-247	Statistics for Lab Sciences
39-319	Law and the Engineer
88-270	Networking: Organizations, Knowledge, and Technology
88-302	Behavioral Decision Making
88-340	Economics of Entrepreneurship in High Technology Industries
90-830	Financial Management of Health System
90-831	Health Management Systems
90-836	Legal Issues in Health Systems Management
90-837	Health Project Planning & Management
90-650	Introduction to Health Care Management
90-853	Health Care Information Systems
90-861	Health Policy

*Since most Electrical and Computer Engineering courses are electives and circuits and signals integral to many medical technologies, a student could use just about any 18-XYZ course where X is greater than 1 and a student can satisfy prerequisites or obtain permission from the instructor.

Students are encouraged to select an interdisciplinary capstone course or independent research project for one of the BME electives.

Like the requirements for the BME double major, the requirements for the BME minor satisfy various categories of electives in the curriculum and should not increase the total number of units/courses required for the primary CIT degree.

Colloids, Polymers and Surfaces

Annette Jacobson, Director Office: Doherty Hall 3102B

The sequence of courses in the Colloids, Polymers and Surfaces (CPS) designated minor provides an opportunity to explore the science and engineering of fine particles and macromolecules as they relate to complex fluids and interfacially engineered materials. These topics are very relevant to technology and product development in industries that manufacture pharmaceuticals, coatings and paints, pulp and paper, biomaterials, surfactants and cleaning products, cosmetics and personal care products, food, textiles and fibers, nanoparticles, polymer/plastics, composite materials.

Course Requirements for Colloids, Polymers and Surfaces Designated Minor

One course from the following list:

06-221	Thermodynamics
24-221	Thermodynamics I
27-215	Thermodynamics of Materials
33-341	Thermal Physics I
09-345	Physical Chemistry II (Thermo)

The following four courses are required:

06-609/09-509	Physical Chemistry of Macromolecules
06-607	Physical Chemistry of Colloids and Surfaces
06-426	Experimental Colloid and Surface Science
06-466	Experimental Polymer Science

Data Storage Systems Technology Designated Minor

William C. Messner, Director Office: Scaife Hall 312

To complete the minor in Data Storage Systems Technology a student must take at least five courses from the list below. Two of the courses must come from the Required Courses list. Introduction to Data Storage Systems (18-416), and Introduction to Solid State Physics (33-448). The student must also take at least three of the elective courses. The various fields related to data storage technology are grouped in to five designated concentration areas — Materials and Chemistry; Physics of Data Storage; Dynamics, Control, and Signal Processing; Computer Systems; and Circuit Design. At least two of the elective courses must be in one of the concentration areas. The required introduction courses provide students with the overview needed for them to develop their interests in a manner consistent with the important aspects of the topic. Completing the courses from a concentration will guarantee that a student will have developed sufficient skill and knowledge to be useful for either employment in industry or for further study at the graduate level.

Course Requirements for Data Storage Systems Technology Minor

Required Courses (Two Undergraduate Courses):

18-416	Data Storage Systems
33-448	Introduction to Solid State Physics

Elective Courses

Materials and Chemistry Concentration

06-607	Physical Chemistry of Colloids and Surfaces
06-609	Physical Chemistry of Macromolecules
06-619	Semiconductor Processing
06-709	Polymeric Materials
06-714	Surfaces and Adsorption
09-348	Inorganic Chemistry
09-511	Solid State Materials Chemistry
27-432	Electronic and Thermal Properties of Metals, Semiconductors and Related Devices
27-542	Structure and Properties of Thin Films

Physics of Data Storage Concentration

33-225	Quantum Physics and the Structure of Matter
33-353	Intermediate Optics
33-448	Introduction to Solid State Physics

A graduate course in quantum physics, magnetism, or optics

Dynamics, Control and Signal Processing Concentration

24-451	Feedback Control Systems
24-356	Engineering Vibrations
18-396	Signals and Systems
18-474	Embedded Control Systems

A graduate course in controls, dynamics, or signal processing

Computer Systems Concentration

15-412	Operating Systems
18-348	Embedded Systems Engineering
18-349	Embedded Real Time Systems
18-549	Embedded Systems Design
18-649	Distributed Embedded Systems

A graduate course in computer systems

Circuit Design Concentration

18-525	Integrated Circuit Design Project
18-545	Advanced Digital Design Project

A graduate course in circuit design

Other Non-Concentration Courses

An independent study project approved by the coordinator of the minor.

Other regular course approved by the coordinator of the minor.

Electronic Materials Designated Minor

David W. Greve, Director Office: Hamerschlag Hall B204
Lisa A. Porter, Co-Director Office: Roberts Engineering Hall 145

Many of the technological changes in recent decades—notably the rise of digital data processing—has been made possible by continuing advances in the performance of electronic devices. These advances include continuous improvement in microprocessor performance, optical communication bandwidth, and magnetic disk storage capacity. Other new areas of innovation include the development of micromechanical systems and the development of flat panel display technology. These advances depend on interactions between engineers from many different disciplines. In particular, there is a strong interaction between device design and materials engineering and processing.

The Electronic Materials Minor is intended to provide students with a firm basis for the application of electronic materials in advanced systems. This minor is well suited for students who intend to pursue careers in the electronics industry (included, but not limited to, semiconductor integrated circuit design and manufacturing, and magnetic storage engineering). The minor also provides an excellent preparation for students interested in pursuing graduate work in MSE, ECE, or Applied Physics.

This minor is primarily intended to offer ECE and MSE students an understanding of the important features that must be built into a material during processing so that it will function as required in an electronic or magnetic device. Other students interested in pursuing this minor should consult their advisors to determine whether it will be practical in their own curriculum. Such students are expected to take both 18-100 and 27-201 as introductory courses.

Students in the Electronic Materials program are urged to consider registering for an undergraduate project in addition to the requirements below, especially if they intend to apply to graduate school. The co-directors will make every effort to arrange a suitable project for interested students.

Faculty Advisors

The designated minor will be administered by the co-directors listed above. Current faculty advisors are:

Chemical Engineering - Paul Sides Civil and Environmental Engineering - Jacobo Bielak Michael Reed and T. E. Schlesinger Engineering and Public Policy - M. Granger Morgan Materials Science and Engineering - Marek Skowronski

Course Requirements for Electronic Materials Minor

The minor requires an introductory course together with a minimum of 48 additional units as specified below.

Required Introductory Courses:

18-100	Introduction to Electrical & Computer Engineering (MSE students)
27-201	Perfect Crystals including lab (ECE students)

Elective Courses:

48 additional units, with 24 units from Group A and 24 units from Group B. Some courses are a required part of one of the curricula and consequently cannot be counted again for the minor program.

We have determined that "courses which are a required part of a curriculum" are those which are specifically named in the curriculum requirements. Consequently technical electives and breadth and depth electives may be double-counted.

Group A

27-202	Defects in Materials (ECE students only)
06-619	Semiconductor Processing Technology
27-542	Thin Films
27-217	Phase Relations (ECE students only)
27-533	Principles of Growth and Processing of Semiconductors
27-432	Electronic, Magnetic, and Optical Properties (only if not required in your curriculum)
27-551	Properties of Ceramics and Glasses
27-216	Transport in Materials (ECE students only)
33-225	Quantum Physics and Structure of Matter (ECE students only)

Group B

18-310	Fundamentals of Semiconductor Devices
18-416	Data Storage Systems
18-715	Physics of Applied Magnetism
18-716	Advanced Applied Magnetism

18-8XX An appropriate 800-level course
(for example, 18-813, 18-815, 18-819).
Other appropriate courses may be substituted with the approval of the coordinators in the event that limited course offerings make it impossible to satisfy the requirements as described above.

Engineering Design Designated Minor

Susan Finger, Director Office: Porter Hall 123B

Design is a pervasive activity in all engineering disciplines. Insuring quality, timeliness, manufacturability and marketability of engineering designs is a crucial concern in product development. The CIT designated minor in Engineering Design is intended to provide a firm methodological basis for engineering design that will be broadly applicable in numerous specialty domains. The minor is intended primarily for engineering undergraduates who want a broader and more formal foundation in design. The requirements for the minor consist of two interdisciplinary design courses which emphasize design methodology, team work, and real-world problem solving, and three elective courses, at least one should involve CAD and at least one should be outside the student's major.

Faculty Advisors

The designated minor in Engineering Design is administered by the Director of the Institute for Complex Engineered Systems. Students undertaking the designated minor can consult with the program advisor in their major department.

Current faculty advisors are:

Chemical Engineering - Larry Biegler and Ignacio Grossman
Civil and Environmental Engineering - Susan Finger and Jim Garrett
Electrical and Computer Engineering - Daniel P. Siewiorek
Engineering and Public Policy - Indira Nair
Mechanical Engineering - Kenji Shimada
Materials Science and Engineering - Robert Heard
Course Requirements for Engineering Design Minor

Required Courses:

Select at least two of the following courses.

39-245 Rapid Prototype Design
39-405 Engineering Design: Creation of Products and Processes
39-600 Integrated Product Development
39-605/606/647 Engineering Design Projects Courses
39-648 Rapid Prototyping of Computer Systems

Elective Courses:

Additional elective courses are required, including at least 9 units outside the student's major department and at least one course involving applications of computer-aided design methods. A total of 45 units is required for the minor, including required and elective courses. Courses can be chosen from the list below, the previous list, or by permission of the Minor Advisors.

Undergraduate Elective Courses:

06-302 Process Engineering and Synthesis
06-606 Computational Methods for Large Scale Process Design & Analysis
12-401 Civil and Environmental Engineering Design
12-605 Design and Construction
12-631 Structural Design
12-675 Computer-Aided Tools for Civil & Environmental Engineers
18-321 Analysis and Design of Analog Circuits
18-322 Analysis and Design of Digital Circuits
18-347 Introduction to Computer Architecture
18-349 Introduction to Embedded Systems
18-360 Introduction to Computer-Aided Digital Design
18-474 Computer Control Systems Design Laboratory
18-517 Data Storage Systems Design Project
18-523 Analog Integrated Circuit Design
18-525 Integrated Circuit Design Project
18-545 Advanced Digital Design Project
18-547 Computer System Design
18-551 Digital Communications and Signal Processing Systems Design
18-575 Control System Design
24-441 Engineering Design
24-442 Engineering Design - EPP
24-443 Design for Manufacture
27-357 Introduction to Materials Selection
27-421 Processing Design
39-647 Independent Study in Engineering Design
42-580 Medical Instrumentation Design

Graduate Elective Courses

06-720 Advanced Process Systems Engineering
12-747 CAE Software Project
12-740 CAE Tools
12-784 Artificial Intelligence for Design
18-725 Digital Integrated Circuit Design
18-748 Dependable System Design
18-760 VLSI CAD: Logic to Layout
18-761 VLSI CAD: Layout to Manufacture
18-763 Physical CAD for VLSI
18-765 Digital System Testing and Testable Design
18-778 Mechatronic Design
18-814 Microelectromechanical Systems
24-788 Mechatronic Design
16-788 Mechatronic Design
24-781 Design Procedures
24-784 Computational Design Tools
27-721 Processing Design

Environmental Engineering and Sustainability Designated Minor

Jeanne VanBriesen, Director
Office: Porter Hall 119

Concern for the environment now influences a wide range of public, private and engineering decisions. Environmental Engineering is widely recognized as a discipline at the graduate and professional level, and undergraduate training in environmental issues and processes can provide the preparation necessary to pursue this career path, or serve as a useful complement to a career in any of the traditional areas of engineering. Sustainability issues are not considered critical across engineering disciplines. Effective preparation requires broad knowledge and skills in the areas of environmental science, environmental engineering and environmental policy.

Faculty Advisors

The Environmental Engineering program is a focus for faculty members from diverse engineering backgrounds. The faculty are actively engaged in teaching and conducting research in this field. Current faculty advisors are:

Biomedical Engineering - Robert Tilton
Chemical Engineering - Neil M. Donahue
Civil and Environmental Engineering - Jeanne VanBriesen
Electrical and Computer Engineering - Marija Ilic
Engineering and Public Policy - Mark Kieler and Edward Rubin
Mechanical Engineering - Allen Robinson
Materials Science and Engineering - Paul Salvador and Robert Heard

Course Requirements for Environmental Engineering and Sustainability Minor

The requirements include two core courses, three technical electives, and two policy electives.

A1. Core Courses in Sustainability (12 units)

Select one set of **two** mini courses from:

19-622 (co-listed as 12-712) Sustainability
19-623 (co-listed as 12-713) Industrial Ecology
OR
19-614 (co-listed as 12-714) Life Cycle Assessment
19-616 (co-listed as 12-715) Case Studies in Sustainability

A2. Core Courses in Environmental Engineering (9 units)

Select **one** NOT in your home major department from:

12-351 Fundamentals of Environmental Engineering
24-424 Energy and the Environment (co-listed as 19-424)
12-651 Air Quality Engineering
24-425 Combustion and Air Pollution Control
12-702 Fundamentals of Water Quality Engineering
06-620 Global Atmospheric Chemistry: Fundamentals and Data Analysis Methods

B. Technical Electives in Environmental Engineering and Sustainability (27 units)

Select **three** from the following list

03-121 Modern Biology
09-106 Modern Chemistry II
09-510 Introduction to Green Chemistry

06-620	Global Atmospheric Chemistry
12-351	Fundamentals of Environmental Engineering
12-651	Air Quality Engineering
12-702	Fundamentals of Water Quality Engineering (new course proposed by CEE for Fall 2008)
12-657	Water Resources Engineering
12-658	Hydraulic Structures Design
24-424	Energy and the Environment
24-425	Combustion and Air Pollution Control
19-622	Sustainability (also listed as 12-712) *
19-623	Industrial Ecology (also listed as 12-713) *
19-614	Life Cycle Assessment (also listed 12-714) *
19-616	Case Studies in Sustainability (also listed as 12-715) *
19-650	Climate and Energy: Science, Economics, and Public Policy
27-322	Processing of Metals **
27-323	Powder Processing of Metals **
27-421	Processing Design *
27-367	Selection and Performance of Materials *
27-594	Electrochemical Processes in Materials
42-621	Biotechnology and Environmental Processes (also listed as 06-621)
48-315	Environment I: Climate and Energy
48-415	Advanced Building
48-596	LEED Building and Green Design Concepts
48-569	GIS/CAFM (also listed as 90-784)
48-572	Zero Energy Housing

- * 6 units; must be combined with 3 additional units
 ** Students may take either 27-322, Processing of Metals, or 27-323, Powder Processing of Metals, but not both, as technical electives in this category.

C. Policy Electives (18 units)

Select **two** from the following list of humanities/social science-oriented courses:

12-608	Implications of Engineering in Global Society
19-448	Science, Technology and Ethics
48-567	Sustainable Design and Development
48-576	Mapping Urbanism
66-210	Science, Technology and the Environment
73-248	Environmental Economics
73-357	Regulation: Theory and Policy
73-358	Economics of the Environment and Natural Resources
73-359	Benefit-Cost Analysis
76-319	Environmental Rhetoric
79-111	Cultural Perspectives on the Environment
79-244	Pittsburgh and the Transformation of Modern Urban America
79-326	The Role of the Environment in the Collapse of Ancient Societies
79-336	Epidemic Disease and Public Health
79-343	Environmental Policy and Development in the Tropical World
79-345	American Environmental History: Critical Issues
79-346	International Environmental Law and Policy (also listed as 88-352)
79-365	Climate Change, Energy Policy and Environmental Protection
79-398	Environmental History and Politics Since Silent Spring (also listed as 88-346)
79-471	American Built Environment Since 1860
79-475	Perspectives on the City and the Environment (also 90-762)
79-211	Disaster! Fires, Plagues, Hurricanes and Floods in American History
79-212	Disastrous Encounters: Technology and the Environment in Global Historical Context
80-242	Conflict and Dispute Resolution
80-244	Environmental Management and Ethics
88-220	Policy Analysis I
88-221	Policy Analysis II
88-223	Decision Analysis and Decision Support Systems
80-340	Environmental Ethics and Decision Processes
99-522	Corporations and Environmental Responsibility
90-747	Cost-Benefit Analysis
90-758	Ethics and Public Policy in a Global Society
90-765	Cities, Technology and the Environment
90-789	Sustainable Community Development
90-798	Environmental Policy and Regulation
90-851	Environmental Policy
90-859	Environmental Conflict Resolution

NOTES:

1. The 48-xxx courses may not be acceptable as technical electives by some CIT engineering departments (At most one of these courses can be used as a Type B course and one as a Type C

2. Course 12-351 Fundamentals of Environmental Engineering can be counted toward completion of the environmental engineering and sustainability course requirements for non-CEE students only.
3. Courses cannot be double-counted for lists A and B.
4. Courses used to fulfill the basic science requirement for CIT cannot be double-counted for list B requirements. Courses required within a student's CIT major can be double-counted for list B requirements.
5. Students may take up to two list B courses in their home department. One list B course must be from outside their home department. EPP double-majors should NOT consider EPP their home department.
6. Other H&SS courses with similar or related content may be substituted for Type C courses with permission of the student's departmental advisor and the Director.
7. A group of three environmental policy courses MAY be counted as fulfilling the H&SS depth requirement required of all CIT students.
8. A list of relevant courses for Type B and C in each semester is provided at the Environmental Engineering and Sustainability Minor website: <http://www.ce.cmu.edu/~dzombak/envminor.html>

International Engineering Studies Designated Minor

Kurt Larsen, Director
 Office: Scaife Hall 110

Many engineers work on international projects or for multinational companies. Carnegie Mellon is an international community, with a significant fraction of international students and many events featuring foreign speakers and cultural experiences. This minor is intended for engineering students interested in broadening their background in international experiences and global awareness and engagement.

Requirements for the minor include:

International Management (1 course)

Complete one course in international management or business such as:

70-342	Managing Across Cultures
70-365	International Trade and International Law
70-381	Marketing I
70-430	International Management

or approved equivalent.

Regional Specialization (1 course)

Complete one course in non-US History, international politics, or literature in a single region of the world. (See page 225 in the undergraduate catalog for a list of courses suggested for Africa, Asia, Europe, Latin America/Caribbean, Middle East and Russia).

Ethics (1 course)

Any ethics course that provides some exposure to international ethics issues such as:

70-332	Business, Society and Ethics
80-243	Business Ethics
80-244	Environment Management and Ethics

or approved equivalent.

Modern Languages

Demonstration of basic competency in a foreign language via one of the three options listed below:

1. Complete one (1) Modern Languages course at the 200 level, with a minimum grade of C, or
2. Achieve a score of 4 or higher in one foreign language Advanced Placement examination, or
3. Demonstrate equivalent proficiency to the satisfaction of the Department of Modern Languages

Study/Work Abroad

Study or engineering internship work abroad for a semester or a summer or participate in an approved short-term global experience program.

Manufacturing Engineering Designated Minor

Bruce H. Krogh, Director Office: Porter Hall B22

The Designated Minor in Manufacturing Engineering provides the student with a background in the basic engineering issues that arise in all manufacturing enterprises, from product design through production processes, to issues in marketing and management.

Faculty Advisors

A faculty member from each department will serve as the faculty advisor for the students who are pursuing the minor degree in their respective departments. Current faculty advisors are:

Chemical Engineering - Arthur Westerberg
 Civil and Environmental Engineering - Susan Finger
 Electrical and Computer Engineering - Bruce H. Krogh
 Engineering and Public Policy - Mark Kieler
 Materials Science and Engineering - Anthony D. Rollett
 Mechanical Engineering - Kenji Shimada

Course Requirements for Manufacturing Engineering Minor

Note: The course lists below are not necessarily current or complete. Appropriate courses not listed below may be counted toward the requirements for the minor upon approval by one of the departmental faculty advisors. Students interested in the Manufacturing Engineering Designated Minor are encouraged to look for applicable courses each semester in CIT, CS, and Robotics.

Two Core Courses:

24-341 Manufacturing Sciences
 27-357 Introduction to Materials Selection (non MSE Majors)
 OR
 27-401 & 402 MSE Capstone Course, I & II (MSE Majors)

Note: Instructor's permission to waive the prerequisites for the core courses will be considered for students pursuing the Manufacturing Engineering Designated Minor.

Technical Electives:

A total of three courses must be selected from at least two of the following categories. Courses taken to fulfill requirements for the student's major, other than technical elective requirements, cannot be used to fulfill this requirement.

Real-Time Systems and Robotics

16-721 Advanced Robot Perception
 16-741 Mechanics of Manipulation
 16-743 Robot Control
 18-348 Embedded Systems Engineering
 18-349 Embedded Real-time Systems
 18-474 Embedded Control Systems
 18-549 Embedded Systems Design
 18-649 Distributed Embedded Systems
 18-778 Mechatronic Design

Design, Materials and Processes

06-362 Chemical Engineering Process Control
 24-443 Design for Manufacture
 27-322 Processing of Metals
 27-323 Processing of Ceramic Materials
 27-421 Design in Process Metallurgy
 27-422 Deformation Processing
 27-592 Solidification Processing
 27-322 Processing Methods
 27-421 Processing Design
 27-442 Deformation Processing
 27-533 Principles of Growth and Processing of Semiconductors
 36-600 Design, Manufacturing and Marketing of New Products
 39-245 Special Topics: Rapid Prototype Design
 39-405 Engineering and Design: the Creation of Products and Processes

Production Management and Control

12-411 Engineering Economics
 12-611 Project Management for Construction
 36-220 Engineering Statistics and Quality Control
 70-430 International Management
 70-371 Production and Operations Management
 70-471 Production II

Language:

Because of the international nature of manufacturing enterprises, students are strongly encouraged to complete one of the following:

82-221/222 Intermediate German: Culture and Society
 82-271/272 Intermediate Japanese

Materials Science and Engineering Designated Minor

Michael E. McHenry, Director
 Office: Roberts Engineering Hall 243

The Designated Minor in Materials Science and Engineering provides the CIT student with a background in the field of Materials Science and Engineering. This minor is open to all CIT students, with the exception of MSE majors. All required and elective courses are taught within the MSE Department.

Course Requirements: The minor requires a minimum of 45 units, with two semester long required courses (the first being a sequence of two minis).

Prerequisites: Students wishing to take the MSE minor must have prerequisite thermodynamics and transport courses. The prerequisite MSE courses may be substituted for by a thermodynamics and transport course in another engineering discipline.

Core Courses (21 units)

Course One (consisting of two half semester minis): 27-201, Perfect Crystals (6 units), 27-202, Defects in Materials (6 units). The laboratories with these courses are not required as core but will be counted as elective units if desired.

Course Two: 27-217, Phase Relations and Phase Diagrams (9 units), again the laboratory with this course will not be required as core but will be counted as elective units if desired.

Elective Courses (24 units minimum)

The student must select a minimum of 24 units from the following list:

27-100 Introduction to Materials Science
 27-201(a) The Structure of Materials (3 units)
 27-202(a) Defects in Materials Laboratory (3 units)
 27-217(a) Phase Relations and Phase Diagrams Laboratory (3 units)
 27-301 Microstructure and Properties
 27-302 Microstructure and Properties II
 27-322 Processing of Metals
 27-323 Processing of Ceramic Materials
 27-357 Introduction to Materials Selection
 27-510 Bio-Materials I
 27-511 Bio-Materials II
 27-582 Phase Transformations in Solids
 27-421 Processing Design
 27-432 Electrical, Magnetic and Optical Properties of Materials
 27-591 Mechanical Behavior of Materials
 27-560 Physical Chemistry of Metallurgical Reactions
 27-454 Supervised Reading
 27-530 Physical Metallurgy with Applications
 27-533 Principles of Growth and Processing of Semiconductors
 27-542 Processing and Properties of Thin Films
 27-551 Properties of Ceramics and Glasses
 27-566 Special Topics
 27-592 Solidification Processing
 42-644 Medical Devices

Mechanical Behavior of Materials

Designated Minor

Warren M. Garrison, Jr., Director
Office: Wean Hall 3303

An understanding of mechanical behavior is important to both the development of new materials and the selection of appropriate materials for many applications. The mechanical behavior of materials is best investigated and understood by integrating solid mechanics with the microstructural basis of flow and fracture. The purpose of this minor is to allow a formal basis for students to pursue an integrated approach to the mechanical behavior of materials.

Although this minor is open to all CIT students, only students in the departments of Civil Engineering, Materials Science and Engineering, and Mechanical Engineering can take advantage of the double counting permitted for some courses in their department majors. Students in other departments may have difficulty in fulfilling the requirements in four years.

Faculty Advisors

Chemical Engineering - Paul Sides
Electrical and Computer Engineering - David W. Greve
Mechanical Engineering - Paul S. Steif
Materials Science and Engineering - Warren M. Garrison, Jr.

Course Requirements

The minor requires six courses: three core courses, two solid mechanics courses, and one materials science course. In satisfying these course requirements, each student must take three out-of-department courses. Each student is required to complete three core courses:

Core Courses:

27-201 Perfect Crystals
27-591(or 27-791) Mechanical Behavior or Materials
12-235(or 24-261) Statics

Group A: Materials Science Courses

Each student must take one course from this list of Materials Science courses:

27-202 Defects in Materials¹
27-357 Selection and Performance of Materials²
27-551 Properties of Ceramics or Glasses
42-511 Biomaterials II
27-530 Advanced Physical Metallurgy

Group B: Solid Mechanics Courses

Each student must take two of the following Solid Mechanics courses:

12-331 Solid Mechanics
or
24-262 Stress Analysis
12-635 Structural Analysis
or
24-351 Dynamics
24-751 Introduction to Solid Mechanics

¹ 27-202 cannot be used by MSE students to satisfy the requirements of the minor.

² 27-357 cannot be used by MSE students to satisfy the requirements of the minor.

Students should check with the director of the program or their faculty advisor for an up-to-date list of relevant courses that will count towards this minor. For more information, please consult the Undergraduate Course Catalog and the current Schedule of Classes.