

University Bulletin

Undergraduate Degree Programs

Primary Navigation

Earth and Mineral Sciences

In the COLLEGE OF EARTH AND MINERAL SCIENCES, instruction and research are aimed at increasing our understanding of the Earth and human interactions with the environment; the production and utilization of fuels and mineral resources; and the science and technology of engineered materials.

Study in the College of Earth and Mineral Sciences covers an unusually wide range, from practical industrial problems, fundamental science, and advanced technology to global environmental issues and human responses to changing social conditions. Degrees are offered in science, engineering, and social science. Programs dealing directly with the Earth and environment include Geosciences, Geobiology, Meteorology, Geography, and Earth Sciences. They also include Energy Business and Finance, as well as Environmental Systems Engineering, which focuses on technologies for environmental clean-up and preservation. The production and utilization of energy and natural resources are the focus of Mining Engineering, Petroleum and Natural Gas Engineering, and Energy Engineering, while areas dealing with engineering materials include the options offered by the Department of Materials Science and Engineering: Ceramic Science and Engineering, Electronic and Photonic Materials, Metals Science and Engineering, and Polymer Science and Engineering. These subjects also seek to advance the science and technology of composite materials.

The following baccalaureate engineering programs are accredited by the Engineering Accreditation Commission of ABET, 415 North Charles Street, Baltimore, MD 20201; telephone 410-347-7700: Mining Engineering, Petroleum and Natural Gas Engineering, Environmental Systems Engineering, Energy Engineering, and Materials Science and Engineering.

UNDERGRADUATE PROGRAMS

PROFESSOR YVETTE P. RICHARDSON, *Associate Dean for Undergraduate Education*

The undergraduate programs of the college provide students with a personal and individual educational experience that helps prepare them for a variety of professional careers. They gain a fundamental understanding of their chosen area, acquire the basic skills and attitudes required to become members of their profession, and have opportunities to meet professionals in their field. Students are challenged to maximize their abilities and prepare for a future in which they will welcome continuous learning and professional growth. Undergraduate student services in the college's Ryan Family Student Center reflect a strong emphasis on communications and mathematics skills, housing full-time faculty tutor-instructors in both writing and math. Research and scholarship are encouraged through participation in capstone design courses, undergraduate theses, or research projects. Field work experience is emphasized in several of the earth science-related majors.

CONCURRENT MAJORS IN LIBERAL ARTS AND EARTH AND MINERAL SCIENCES--For a student who wishes to earn a liberal arts degree combined with technical preparation for a career in the earth, mineral, or materials sciences, the college offers a concurrent major program, requiring ten semesters of study, the first six in the College of the Liberal Arts and the last four in the College of Earth and Mineral Sciences. Upon completion of the program, a B.A. is awarded by the College of the Liberal Arts and a B.S. by the College of Earth and Mineral Sciences. The latter degree may be earned in any of the college's science or engineering programs.

3-2 PROGRAM WITH OTHER INSTITUTIONS AND EARTH AND MINERAL SCIENCES--In the cooperative liberal education 3-2 Program, the student completes three academic years of study in one of the EMS engineering programs at one of several cooperating liberal arts colleges and then transfers to Penn State for two additional academic years (four semesters). Upon completion of the program, the student is awarded the B.A. degree by the liberal arts college and the B.S. degree by this university. Arrangements for the cooperative program are in effect with several colleges in the state. Inquiries concerning admission should be made at the Earth and Mineral Sciences Ryan Family Student Center in 14 Deike Building, University Park campus.

TEACHER CERTIFICATION PROGRAMS--It is possible, with careful planning, for students to satisfy requirements for the provisional certificate for teaching in the Commonwealth of Pennsylvania while also satisfying requirements for the bachelor's degree in any major in the College of Earth and Mineral Sciences. Students who want to prepare for teaching certification should consult the certification officer of the College of Education or the Office of the Associate Dean for Education.

RECOMMENDED ACADEMIC PLANS

Recommended Academic Plans provide, in table form, the courses students might schedule semester by semester as they pursue a specific undergraduate degree. Each college or campus maintains Recommended Academic Plans for its own majors/degree programs. Links to these plans are on the Division of Undergraduate Studies website at: <http://www.dus.psu.edu/semplans.htm>. Questions concerning the Recommended Academic Plans should be directed to the college or campus involved or the Division of Undergraduate Studies.

INTERNATIONAL STUDY OPPORTUNITIES

There are many ways students may take advantage of a global education, through education abroad opportunities, international internships, and focused international experiences for outstanding juniors and seniors. For more

information refer to: www.ems.psu.edu/current_undergrad_students/study_abroad

ENGINEERING COOPERATIVE EDUCATION PROGRAM

Students enrolled in the College of Earth and Mineral Sciences engineering programs are eligible for opportunities to pursue up to one full year of career-related experience while earning their undergraduate degree through the Engineering Cooperative Education and Professional Internship Program. For additional information refer to: www.engr.psu.edu/coop

CONTINUING AND DISTANCE EDUCATION

Penn State students may acquire course credit in a number of ways in addition to classroom instruction. The World Campus, Penn State's online campus, offers a number of General Education and U.S. and International Cultures courses. See the World Campus Web site www.worldcampus.psu.edu for information regarding prerequisites, registration, and payments. Through the John A. Dutton e-Education Institute (<https://www.e-education.psu.edu>), students may pursue certificate programs through the Departments of Geography and Meteorology: Post-baccalaureate Certificate in Geographic Information Systems; Post-baccalaureate Certificate in Geospatial Intelligence; and Certificate of Achievement in Weather Forecasting. Effective fall 2010, the John A. Dutton e-Education Institute, in conjunction with the Department of Energy and Mineral Engineering and the World Campus, will offer an online bachelor of arts degree in Energy and Sustainability Policy.

DIVERSITY IN EARTH AND MINERAL SCIENCES

Diversity among students and faculty is a top priority for the dean and the faculty of the College of Earth and Mineral Sciences. We are committed not only to recruiting and retaining our students, but also to helping them to develop professionally and to graduate. Initiatives to enhance diversity include enhancing educational opportunities for underrepresented students; creating alliances by partnering with HBCUs and other minority-serving institutions; and enhancing the EMS cultural environment to promote educational equity.

COLLEGE OF EARTH AND MINERAL SCIENCES

LEE KUMP, *Dean*

JOHN R. HELLMANN, *Associate Dean for Graduate Education and Research*

YVETTE P. RICHARDSON, *Associate Dean for Undergraduate Education*

VICTORIA E. SANCHEZ, *Associate Dean for Educational Equity*

COLLEGE ORGANIZATION

Energy and Mineral Engineering

SANJAY SRINIVASAN, *Department Head*

SETH BLUMSACK, *Associate Head for Undergraduate Education*

LUIS F. AYALA H., *Associate Head for Graduate Education*

Geography

CYNTHIA A. BREWER, *Department Head*

LORRAINE DOWLER, *Associate Head for Undergraduate Programs*

BRIAN KING, *Associate Head for Resident Graduate Programs*

Geosciences

TIMOTHY BRALOWER, *Interim Department Head*

MAUREEN FEINEMAN, *Associate Head for Undergraduate Programs*

Materials Science and Engineering

SUSAN SINNOTT, *Department Head*

R. ALLEN KIMMEL, *Associate Head for Undergraduate Studies*

Meteorology

DAVID J. STENSRUD, *Department Head*

JON M. NESE, *Associate Head for Undergraduate Programs*

Baccalaureate Degrees

Earth Science and Policy

University Park, College of Earth and Mineral Sciences (EARSP)

PROFESSOR PETER J. HEANEY, *Associate Head for Undergraduate Programs*

Global climate change and environmental change on a more local scale present major challenges for our future. The solution to these problems requires people with a solid scientific understanding of natural earth/environmental systems, and also an understanding of the social, economic, and political dimensions of these problems. This major is intended to bridge the gap between the physical, natural sciences (the earth sciences) and the social sciences, with the

understanding that intelligent, effective solutions to environmental problems will require people who grasp the scientific and social dimensions of environmental problems. This major is intended to produce graduates who not only grasp these problems, but who can also apply a wide array of quantitative tools and fundamental principles to generate practical solutions.

Students develop a sense of community through a set of common upper level courses and they gain practical experience through a mandatory internship course. A variety of options are offered to enable greater depth of study in aspects of science and policy related to water and land use, climate change, and energy; a general option is also available.

This major will provide an excellent preparation for careers in environmental law, environmental consulting, and non-profit organizations engaged in the science and policy of environmental issues. This major will also serve as a strong basis for postgraduate studies in environmental science and policy.

WATER AND LAND USE OPTION: This option is intended to develop a focus on the role of water and land in environmental issues, encompassing scientific, economic, and policy dimensions of groundwater and surface water resources and of land use. The Water and Land Use option is appropriate both for students who intend to pursue postgraduate degrees and for students who want to enter the work force.

CLIMATE CHANGE OPTION: This option is intended for students who want to focus on the science and policy related to climate change, including the scientific basis for identifying, understanding, and potentially mitigating climate change. The option also develops a basis for understanding the economic costs and risks related to climate change, as well as the political dimensions. This option is appropriate both for students who intend to pursue postgraduate degrees and for students who want to enter the work force.

ENERGY OPTION: This option is designed to provide a focus on aspects of Earth science and policy related to energy, including the origins of energy and mineral resources, the future of these resources, and the alternatives for meeting future needs. This option also provides a focus on the economics of energy systems and the political dimensions of the challenges related to our energy future. The Energy option is appropriate both for students who intend to pursue postgraduate degrees and for students who want to enter the work force.

GENERAL OPTION: This option is intended for students who desire a broad sampling of Earth science as it relates to policy or those who desire to design their own focus within Earth science in consultation with an academic adviser. The General option is appropriate both for students who intend to pursue postgraduate degrees and for students who want to enter the work force.

For the B.S. degree in Earth Science and Policy, a minimum of 120 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits (33 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR) (See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR: (Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES: (Included in GENERAL EDUCATION course selection or REQUIREMENTS FOR THE MAJOR)

WRITING ACROSS THE CURRICULUM: (Included in REQUIREMENTS FOR THE MAJOR)

ELECTIVES: 0-2 credits

REQUIREMENTS FOR THE MAJOR: 106-108 credits (This includes 33 credits of General Education courses: 9 credits of GN courses; 6 credits of GQ courses; 9 credits of GWS courses; 3 credits of GH courses; 6 credits of GS courses.)

COMMON REQUIREMENTS FOR THE MAJOR (ALL OPTIONS): 79-81 credits

PRESCRIBED COURSES (49 credits)

BIOL 110 GN(4), CHEM 110 GN(3), CHEM 111 GN(1), CHEM 112 GN(3), CHEM 113 GN(1), ECON 102 GS(3), EMSC 100 GWS(3) [71], GEOG 126 GS;US;IL(3), PHIL 118 GH(3), PLSC 001 GS(3), STAT 200 GQ(4) (Sem: 1-4)

EARTH 202(3) [11] (Sem: 6)

EBF 472(3) [11], GEOG 364(3), GEOSC 450(3) [11] (Sem: 6-8)

EARTH 400(3), EARTH 495(3) (Sem: 7-8)

ADDITIONAL COURSES (30-32 credits)

ENGL 015 GWS(3) or ENGL 030 GWS(3) (Sem: 1-2)

MATH 083 GQ(4) [11] or MATH 110 GQ(4) [11] or MATH 140 GQ(4) [11] (Sem: 1-2)

GEOSC 001(3) or GEOSC 020 GN(3) (Sem: 1-4)

MATH 111 GQ(2) or MATH 141 GQ(4) (Sem: 2-3)

PHYS 211(4) or PHYS 250(4) (Sem: 2-3)

CAS 100 GWS(3) or ENGL 202C GWS(3) (Sem: 2-5)

CED 201(3) or EBF 200 GS(3) (Sem: 2-5)

Select 8 credits from: GEOSC 201(4) [11], GEOSC 202(4) [11], GEOSC 203(4) [11] (Sem: 3-6)

REQUIREMENTS FOR THE OPTION: 27 credits

WATER AND LAND USE OPTION: (27 credits)

ADDITIONAL COURSES (27 credits) Must include one W course

Select 3 credits from: EARTH 111 GN;US(3), GEOG 160 GS(3), SOILS 101 GN(3) (Sem: 2-5)

Select 12 credits from: ERM 300(3), FOR 455(3), FOR 470(3), GEOG 363(3), GEOSC 340(3), GEOSC 402 IL(3), GEOSC 409(3), GEOSC 413(3), GEOSC 452(3), GEOSC 483(3), SOILS 415(3), SOILS 422(3), SOILS 450(3) (Sem: 3-8)

Select a total of 12 credits from the following:

3 to 6 credits from: CED 429(3), CED 431(3), ECON 302 GS(3) (Sem: 4-8)

6 to 9 credits from: CED 309(3), CED 409(3), CED 410(3), GEOG 430(3), GEOG 431(3), GEOG 434(3), GEOG 439(3), PLSC/STS 460(3), PUBPL 481(3) (Sem: 4-8)

CLIMATE CHANGE OPTION: (27 credits)

ADDITIONAL COURSES: (27 credits) Must include one W course

Select 3 credits from: EARTH 002 GN(3), GEOG 110 GN(3), METEO 003 GN(3), METEO 004 GN(3) (Sem: 2-5)

Select 12 credits from: GEOG 310(3), GEOG 412(3), GEOSC 320(3), GEOSC/METEO 475(3), METEO 201(3), METEO 466(3) (Sem: 4-8)

Select a total of 12 credits from the following:

3 to 6 credits from: CED 429(3), CED 431(3), ECON 302(3) (Sem: 4-8)

6 to 9 credits from: CED 230(3), CED 410(3), EMSC/STS/SOC 420(3), GEOG 430(3), GEOG 434(3), GEOG 438W(3), PLSC/STS 460(3), STS 201(3) (Sem: 4-8)

ENERGY OPTION: (27 credits)

ADDITIONAL COURSES: (27 credits) Must include one W course

Select 3 credits from: EARTH 100 GN(3), EGEE 101 GN(3), EGEE 102 GN(3) (Sem: 2-5)

Select 9 credits from: EGEE 302(3), EGEE 401(3), EGEE 412(3), GEOSC 451(3), GEOSC 454(3), GEOSC 483(3) (Sem: 4-8)

Select 3 credits from: EBF 484(3), GEOG 424 US;IL(3) (Sem: 4-8)

Select 12 credits from: CED 230(3), CED 410(3), EMSC/STS/SOC 420(3), GEOG 430(3), GEOG 434(3), GEOG 438(3), GEOG 439(3), PLSC/ STS 460(3), STS 201 GN(3) (Sem: 4-8)

GENERAL OPTION: (27 credits)

ADDITIONAL COURSES: (27 credits) Must include one W course

Select 3 credits from: EARTH 002 GN(3), EARTH 100 GN(3), EARTH 111 GN;US(3), EGEE 101 GN(3), GEOG 010 GN (3), GEOG 030 GS(3), GEOG 160 GS(3), METEO 003 GN(3), METEO 004 GN(3), SOILS 101 GN(3) (Sem: 2-5)

Select 12 credits from: ERM 300(3), EGEE 302(3), EGEE 412(3), FOR 455(3), FOR 470(3), GEOG 310(3), GEOG 363(3), GEOG 412(3), GEOSC 320(3), GEOSC 340(3), GEOSC 402 IL(3), GEOSC 409(3), GEOSC 413(3), GEOSC 451(3), GEOSC 452(3), GEOSC 454(3), GEOSC 483(3), METEO 466(3), SOILS 415(3), SOILS 422(3), SOILS 450(3) (Sem: 4-8)

Select a total of 12 credits from the following:

3 to 6 credits from: CED 429(3), CED 431(3), EBF 484(3), ECON 302 GS(3), GEOG 424 US;IL(3), (Sem: 4-8)

6 to 9 credits from: CED 230(3), CED 309(3), CED 409(3), CED 410(3), ERM 411(3), GEOG 130 GS(3), GEOG 430(3), GEOG 431(3), GEOG 434(3), GEOG 438(3), GEOG 439(3), EMSC/STS/SOC 420(3), PLSC 403(3), PLSC 412(3), PLSC 426(3), PLSC/STS 460(3), PLSC 471(3), PLSC 490(3), STS 201(3) (Sem: 4-8)

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[71] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS or ENGL 202C GWS can be substituted for EM SC 100S GWS.

Last Revised by the Department: Fall Semester 2011

Blue Sheet Item #: 40-01-052

Review Date: 08/16/2011

Earth Sciences

University Park, College of Earth and Mineral Sciences (EARTH)

PROFESSOR PETER J. HEANEY, *Associate Head for Undergraduate Programs*

This major provides a comprehensive program in environmental sciences based on a strong emphasis in earth sciences. It is especially directed toward study of the problems that arise from the complex interaction of man's technological and social activities with the natural environment. Graduates are in demand for positions in government, industry, and consulting. Professional activities include gathering and evaluating data on environments; management and coordination of specialized programs in environmental control and modification; and industrial and government planning. Suitable choices of courses may qualify students for graduate work in several fields.

For the B.S. degree in Earth Sciences, a minimum of 123 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits

(21 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)

(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:

(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in GENERAL EDUCATION course selection)

WRITING ACROSS THE CURRICULUM:

(Included in REQUIREMENTS FOR THE MAJOR)

REQUIREMENTS FOR THE MAJOR: 99-101 credits

(This includes 21 credits of General Education courses; 9 credits of GN courses; 6 credits of GQ courses; 6 credits of

GWS courses.)

PRESCRIBED COURSES (31 credits)

CHEM 110 GN(3), CHEM 111 GN(1), CHEM 112 GN(3), CHEM 113 GN(1), EMSC 100 GWS(3) [71], MATH 140 GQ(4), MATH 141 GQ(4) (Sem: 1-2)
PHYS 211 GN(4), PHYS 212 GN(4) (Sem: 1-4)
BIOL 110(4) (Sem: 3-4)

ADDITIONAL COURSES (36 credits)

ENGL 015 GWS(3) or ENGL 030 GWS(3) (Sem: 1-2)

Select 15 credits of introductory earth science from the following list (courses may not double count with minor requirements): EARTH 002 GN(3), EARTH 101 GN(3), EARTH 103 GN(3), EARTH 105 GN(3), METEO 003 GN(3), METEO 022(2), GEOG 030 GS;IL(3), GEOG 110 GN(3), GEOG 111 GN(3), GEOG 115 GN(3), GEOG 160(3), GEOSC 001(3), GEOSC 021 GN(3), SOILS 101 GN(3) (Sem: 1-6)

Select 15 credits [1] of advanced earth science from the following list (courses may not double count with minor requirements): GEOG 430(3), GEOG 438(3), GEOG 412(3), GEOSC 204(4), GEOSC 320(3), GEOSC 340(3), GEOSC 402(3), GEOSC 416(3), METEO 300(4), METEO 431(3), METEO 475(3) (Sem: 3-8)

Select 3 credits of writing-intensive courses from within Earth and Mineral Sciences to include, but not limited to: GEOG 412(3), GEOG 310(3), GEOSC 402(3), GEOSC 470(3), METEO 471(3) (Sem: 7-8)

SUPPORTING COURSES AND RELATED AREAS (32-34 credits)

Select 3-4 credits of advanced math, statistics, computer science in consultation with an adviser (Sem: 5-8)

Select 3 credits of field, laboratory experience in consultation with an adviser (Sem: 5-8)

Select 8-9 credits in other approved courses (Students may apply 6 credits of ROTC) (Sem: 5-8)

Select 18 credits [1], in consultation from an adviser, from one of the following Earth and Mineral Sciences interdisciplinary minors:

CLIMATOLOGY

MARINE SCIENCE

WATERSHEDS & WATER RESOURCES

EARTH SYSTEMS

GLOBAL BUSINESS STRATEGIES FOR EARTH AND ENVIRONMENTAL INDUSTRIES

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[71] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS or ENGL 202C GWS can be substituted for EM SC 100S GWS.

Last Revised by the Department: Summer Session 2000

Blue Sheet Item #: 28-05-017

Review Date: 1/20/04

UCA Revision #1: 8/3/06

Department Head Change: 4/12/05

EM

Energy and Sustainability Policy

University Park, College of Earth and Mineral Sciences offered via the World Campus

VERA COLE, *Program Officer*

The Bachelor of Arts degree in Energy and Sustainability Policy (ESP) is an interdisciplinary program, preparing students for careers in the evolving policy sector of the energy and sustainability fields. ESP will help students achieve five broad educational objectives: (1) energy industry knowledge; (2) a sustainability ethic; (3) analytical skills; (4) communication skills; and (5) global perspective. Graduates will be prepared to act as agents for stakeholders, facilitating communication, design, and planning between the executive wing and operations wing of organizations, including commercial firms, NGOs, and governmental bodies. The online program serves a national market of adult learners who need to participate part-time and at a distance.

For the B.A. degree in Energy and Sustainability Policy a minimum of 120 credits is required.

Scheduling recommendation by semester standing given as (Sem: 1-2)

GENERAL EDUCATION: 45 credits

(25 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR). (See description of General Education in this bulletin)

FIRST-YEAR SEMINAR: 1 credit

Undergraduate programs delivered through the World Campus are exempt from the FYS requirement. However, the B.A. in ESP program will require a comparable 1-credit Program Orientation course (EM SC 302) that introduces students to program objectives and advising resources.

UNITED STATES CULTURES AND INTERNATIONAL CULTURES: (Included in GENERAL EDUCATION course selections or REQUIREMENTS FOR THE MAJOR.)

WRITING ACROSS THE CURRICULUM: (Included in the REQUIREMENTS FOR THE MAJOR.)

BACHELOR OF ARTS REQUIREMENTS: 24 credits

(See description of Bachelor of Arts Degree Requirements in this bulletin.)

ELECTIVES: 8

REQUIREMENTS FOR THE MAJOR: 68 credits

(This includes 25 credits of General Education Courses: 6 credits of GN courses, 9 credits of GWS courses, 4 credits of GQ courses, and 6 credits of GS courses.)

PRESCRIBED COURSES: 62 credits

CAS 100 GWS(3), EBF 200 GS(3)[11], ECON 102 GS(3), ECON 104 GS(3), EGEE 102 GN(3)[11], EGEE 120 GS;US;IL(3), EGEE 401(3), EMSC 240(3), EMSC 302(1)[11] (Sem: 1)
METEO 469(3)[11], PLSC 1 GS(3) (Sem: 1-2)
STAT 200 GQ(4)[11] (Sem: 3-4)
EME 444(3)[11], EME 466(3)[11], ENGL 015 GWS(3), ENGL 202D GWS(3), GEOG 030 GS;IL(3)[11] (Sem: 5)
GEOG 432(3)[11], GEOG 469(3)[11] (Sem: 6)
PLSC 490(3)[11] (Sem: 7)
GEOG 438(3)[11] (Sem: 8)

ADDITIONAL COURSES: 6 credits

METEO 3 GN(3) or METEO 101 GN(3) (Sem: 5)
EGEE 299 IL(3) or EGEE 495(3) (Sem: 8)

[11] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

Last Revised by the Department: Spring Semester 2016

Blue Sheet Item #: 44-06-033C

Review Date: 4/5/2016

Energy and Sustainability Policy

University Park, College of Earth and Mineral Sciences *offered via the World Campus (ESPBS)*

The Bachelor of Science degree in Energy and Sustainability Policy (ESP) is an interdisciplinary program, preparing students for careers in the evolving policy sector of the energy and sustainability fields, especially where strong science, business, and analytical skills are required. The B.S. program prescribes coursework in areas including energy sources, uses, and technologies; sustainability principles and practices; climate change; and, policy development and analysis. Students select additional courses in energy and science; analysis and technology; business and management; and, ethics, leadership and communications. ESP B.S. educational objectives emphasize five areas of student competency: (1) energy industry knowledge; (2) a sustainability ethic; (3) analytical skills; (4) communication skills; and (5) global perspective. The ESP B.S. program prepares students with knowledge and skills valued by many types of organizations, including commercial firms, government agencies, public utilities, regulatory bodies, nonprofit and advocacy groups, and energy and trade organizations.

For the B.S. degree in Energy and Sustainability Policy a minimum of 120 credits is required.

Scheduling recommendation by semester standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits

(25 of these 45 are included in the REQUIREMENTS FOR THE MAJOR.)

(See descriptoin of General Education in the bulletin.)

FIRST-YEAR SEMINAR: 1 credit

Undergraduate programs delievered through the World Campus are exempt from the FYS requirement. However, the B.S. in ESP program requires a comparable 1-credit Program Orientation course (EMSC 302) that introduces students to program objectives and advising resources.

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in GENERAL EDUCATION course selections or REQUIREMENTS FOR THE MAJOR.)

WRITING ACROSS THE CURRICULUM:

(Included in the REQUIREMENTS FOR THE MAJOR.)

ELECTIVES: 11

REQUIREMENTS FOR THE MAJOR: 89 credits

(This includes 25 credits of General Education Courses: 6 credits of GN courses, 9 credits of GWS courses, 4 credits of GQ courses, and 6 credits of GS courses.)

PRESCRIBED COURSES (62 credits)

CAS 100 GWS(3), EBF 200 GS(3)[11], ECON 102 GS(3), ECON 104 GS(3), EGEE 102 GN(3)[11], EGEE 120 GS;US;IL(3), EGEE 401(3), EMSC 240(3), EMSC 302(1)[11] (Sem: 1)
METEO 469(3)[11], PLSC 1 GS(3) (Sem: 1-2)
STAT 200 GQ(4)[11] (Sem: 3-4)
ENGL 015 GWS(3), ENGL 202D GWS(3), GEOG 30 GS;IL(3)[11] (Sem: 5)
GEOG 469(3)[11] (Sem: 6)
PLSC 490(3)[11] (Sem: 7)
EME 444(3)[11], EME 466(3)[11] (Sem: 8)
GEOG/EME 432(3)[11], GEOG 438(3)[11] (Sem: 8)

ADDITIONAL COURSES (6 credits)

METEO 3 GN(3) or METEO 101 GN(3) (Sem: 5)
EGEE 299 IL(3) or EGEE 495(3) (Sem: 8)

SUPPORTING COURSE AND RELATED AREAS (21 credits)

Select 6 credits in ENERGY AND SCIENCE from an approved list or in consultation with adviser.

Select 6 credits in ANALYSIS AND TECHNOLOGY from an approved list or in consultation with adviser.

Select 6 credits in BUSINESS AND MANAGEMENT from an approved list or in consultation with adviser.

Select 3 credits in ETHICS, LEADERSHIP AND COMMUNICATION from an approved list or in consultation with adviser.

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

Blue Sheet Item #: 44-06-034

Review Date: 4/5/2016

Energy Business and Finance

University Park, College of Earth and Mineral Sciences (EBF)

University Park, Smeal College of Business

Professor Seth Blumsack, Undergraduate Program Chair

The major in Energy Business and Finance, offered jointly by the College of Earth and Mineral Sciences and the Smeal College of Business, combines training in business, economics, finance, and the physical sciences with a core of courses focusing on energy and related industries. The major helps students prepare for careers in the energy industry, as well as financial institutions, nonprofit groups, and international organizations dealing with energy issues. The curriculum also provides a strong base for further study in business, economics, law, and social sciences.

Entrance Requirement: To be eligible for entrance into the Energy Business and Finance major, a degree candidate must satisfy requirements for entrance to major. Specific entrance requirements include:

1. The degree candidate must have completed more than 29.1 credits of course work.
2. The degree candidate must have a cumulative grade point average of at least 2.0.
3. Complete the following entrance to major requirements: ECON 102 GS(3)[1], MATH 140 GQ(4)[1].

GENERAL OPTION

The General option of the Energy Business and Finance major is appropriate for students who want a broad understanding of the earth and environmental sciences in preparation for careers in industry, commerce, and government.

ENERGY LAND MANAGEMENT OPTION

The Energy Land Management Option in the major of Energy Business and Finance focuses on issues in the acquisition of sub-surface exploration rights. Thus, it is designed to prepare students for a career as a land professional in an energy exploration company. The curriculum, designed in consultation with the American Association of Professional Landmen, requires courses in real estate fundamentals, energy law, geographic information sciences, petroleum engineering and petroleum geology.

Integrated B.S. in Energy Business and Finance (EBF) and M.S. in Energy and Mineral Engineering (EME)

The integrated undergraduate-graduate (IUG) program between the Energy Business and Finance undergraduate program and the Energy and Mineral Engineering graduate program enables academically superior and research-focused EBF undergraduate students to also obtain an M.S. degree in Energy and Mineral Engineering in five years of study. Students should refer to the Energy and Mineral Engineering graduate program in the Graduate Program Bulletin for the IUG admission and degree requirements.

(http://bulletins.psu.edu/bulletins/whitebook/graduate_degree_programs.cfm?letter=E&program=grad_eme.htm)

For the B.S. degree in Energy Business and Finance, a minimum of 120 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits

(25-27 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)

(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:

(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in REQUIREMENTS FOR THE MAJOR)

WRITING ACROSS THE CURRICULUM:

(Included in REQUIREMENTS FOR THE MAJOR)

ELECTIVES: 0-12 credits**REQUIREMENTS FOR THE MAJOR: 90-102 credits**

(This includes 25-27 credits of General Education Courses: 4-6 credits of GN courses, 9 credits of GWS courses, 6 credits of GQ courses, and 6 credits of GS courses.)

COMMON REQUIREMENTS FOR THE MAJOR (ALL OPTIONS): 66 credits**PRESCRIBED COURSES (45 credits)**

MATH 140 GQ(4)[1] (Sem: 1)

ECON 102 GS(3)[1] (Sem: 1)

MATH 141 GQ(4)[11] (Sem: 2)
EBF 200 GS(3)[11] (Sem: 3)
ACCTG 211(4), ECON 104 GS(3), ECON 302 GS(3)[11] (Sem: 3-4)
EBF 301(3)[11], EBF 304(3)[11] (Sem: 5-6)
EME 460(3)[11], IB 303 IL(3) (Sem: 5-8)
RM 302(3)[11] (Sem: 6-8)
EBF 401(3)[11], EBF 473(3) (Sem: 7-8)

ADDITIONAL COURSES (21 credits)

Select 3 credits from: CAS 100 GWS(3) or EMSC 100S GWS(3) (Sem: 1)
Select 3 credits from: CMPSC 101 GQ(3), CMPSC 200 GQ(3), CMPSC 201 GQ(3), CMPSC 202 GQ(3) (Sem: 1-2)
Select 3 credits from: ENGL 015 GWS(3) or ENGL 030 GWS(3) (Sem: 1-2)
Select 3 credits from: BA 243(4), BLAW 243(3), or ERM 411(3) (Sem: 3-4)
Select 3 credits from: EBF 472(3)[11], STAT 301 GQ(3)[11], or STAT 401(3)[11] (Sem: 3-4)
Select 3 credits from: EBF 483(3)[11] or EBF 484(3)[11] (Sem: 7-8)
Select 3 credits from: ENGL 202C GWS(3) or ENGL 202D GWS(3) (Sem: 7-8)

REQUIREMENTS FOR THE OPTION: 24-36 credits

ENERGY LAND MANAGEMENT OPTION (25 credits)

PRESCRIBED COURSES (12 credits)

GEO SC 001(3)[1] (Sem: 1-2)
GEOG 160 GS(3)[11], GEOG 363(3) (Sem: 5-8)
EBF 402(3) (Sem: 7-8)

ADDITIONAL COURSES (13 credits)

Select 4 credits from: PHYS 211 GN(4)[1] or PHYS 250 GN(4)[11] (Sem: 1-2)
Select 3 credits from: GEOG 361(3)[11], GEOG 362(3)[11], GEOG 364(3)[11], or GEOG 463(3)[11] (Sem: 5-6)
Select 3 credits from: EBF 411(3) or GEO SC 454(3) (Sem: 7-8)
Select 3 credits from: EBF 410(3) or PNG 405(3) (Sem: 7-8)

GENERAL OPTION: (24-36 credits)

ADDITIONAL COURSES (9-10 credits)

Select 6-7 credits from: CHEM 110 GN(3), EARTH 100 GN(3), EARTH 101 GN;US(3), EARTH 103 GN(3), EARTH 111 GN;US(3), EARTH 150 GN(3), EGEE 101 GN(3), EGEE 102 GN(3), EGEE 120 GS;US;IL(3), GEOG 110 GN(3), GEOG 115 GN(3), GEO SC 002 GN(3), GEO SC 010 GN(3), GEO SC 020 GN(3), GEO SC 021 GN(3), GEO SC 040 GN(3), MATSE 081 GN;IL(3), METEO 003 GN(3), METEO 101 GN(3), PHYS 211 GN(4) or PHYS 250 GN(4) (Sem: 1-4)
Select 3 credits from: CED 404(3), CED 429(3), CED 431(3), EBF 411(3), EBF 483(3)[if not selected for requirement above], ECON 490(3), EME 301(3), GEOG 424 US;IL(3), GEOG 430(3), GEOG 431(3), GEOG 444(3), GEOG 493(3), GEO SC 402 IL(3), GEO SC 454(3), METEO 473(3), PL SC 490(3) (Sem: 5-8)

SUPPORTING COURSES AND RELATED AREAS (15-26 credits)

Select either:

Select from one of the following minors:

Arabic, Chinese, Civic and Community Engagement, Earth Systems, Energy Engineering, Entrepreneurship and Innovation, Environmental Resource Management, Environmental Systems Engineering, Geographic Information Science, Geosciences, Mathematics, Meteorology, Mining Engineering, Petroleum and Natural Gas Engineering, Russian, Spanish, Statistics, Watersheds and Water Resources or a relevant minor selected in consultation with an adviser;

Or

A concurrent major in any subject;

Or

A 15 credit semester-long education abroad program approved by the professor in charge of the E B F major;

Or

A minor in Asian Studies together with an approved E B F summer term abroad experience.

Course Substitutions for the Integrated B.S. in Energy Business and Finance (EBF) and M.S. in Energy and Mineral Engineering (EME)

As many as twelve of the credits required for the master's degree may be applied to both the B.S. and M.S. degrees. A minimum of six credits counted for both the B.S. and M.S. degrees must be at the 500-level. Thesis and culminating/capstone experience credits may not be double counted. The undergraduate degree program officer will determine the specific undergraduate required courses for which the 500-level courses may be used to substitute to meet institutional and accreditation requirements.

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

Last Revised by the Department: Spring Semester 2015

Blue Sheet Item #: 43-06-056

Review Date: 4/14/2015

Minor editorial changes to comply with University editorial style (Publications): 8/23/06

EM

Energy Engineering

University Park, College of Earth and Mineral Sciences (ENENG)

PROFESSOR SARMA V. PISUPATI, Undergraduate Program Chair

The undergraduate program in energy engineering is designed to reflect the growing impact and demand for energy in society and to equip students with the knowledge necessary to achieve the following career and professional goals: become valuable contributors in addressing society's energy needs and demands; successful leaders in advancing the technology and management of energy; innovators and entrepreneurs in the energy sector; and educators, practicing engineers, and national leaders on energy and associated environmental, health and safety, and policy and economics issues. The program integrates skill sets in the physical sciences (chemistry, engineering, mathematics, and physics) and social sciences (economics, policy, and management) to ensure successful career opportunities and growth within energy-related industries, government agencies, and academia.

The courses are structured to enable students to understand engineering fundamentals and apply the knowledge to solve problems in the production, processing, storage, distribution, and utilization of energy using multiple techniques as synthesis, analysis, design and case studies. Inquiry-based teaching methods and lab experiences are emphasized. The faculty research and scholarly activities are integrated into the curriculum. The program is designed to train students to be lifelong learners, problem solvers, and energy industry leaders. The educational opportunities are sufficiently flexible, broad, and diverse to enable students to tailor their educational experience to particular interests, background, and expected role in society. Flexibility in the curriculum allows other students in energy related programs such as agricultural and biological, chemical, civil, electrical, environmental, mechanical, mining, nuclear, and petroleum engineering, materials science and engineering, industrial health and safety, and energy business and finance to have dual or concurrent degrees, minors, or options (e.g., energy and fuels engineering option in chemical engineering).

The integration of knowledge and skills acquired during the course of study in the Energy Engineering program provides graduates with the following student outcomes:

1. An ability to apply knowledge of mathematics, science, and engineering
2. An ability to design and conduct experiments, as well as to analyze and interpret data
3. An ability to design a system, component, or process to meet desired needs
4. An ability to function on multi-disciplinary teams
5. An ability to identify, formulate, and solve engineering problems
6. An understanding of professional and ethical responsibility
7. An ability to communicate effectively
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context
9. A recognition of the need for and an ability to engage in life-long learning
10. A knowledge of contemporary issues
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Energy Engineering Program Educational Objectives

Our graduates will be:

1. Employed in the public or private sectors in the areas of energy science, energy engineering or energy business management, or pursuing an advanced degree.
2. Contributing to development of solutions to society's current energy needs by integrating key science and engineering principles while being adaptable to changing organizational and societal needs;
3. Engaged in individual projects and multi-disciplinary teams designing, evaluating, and recommending methods and strategies for the efficient production, processing and utilization of renewable or non-renewable energy and addressing the associated environmental challenges;
4. Effectively communicating with management, coworkers, customers, clients and others in diverse environments;
5. Engaged in life-long learning process to maintain professional competency through training, participation in professional activities and leadership.

Entrance to Major Requirements:

In addition to the minimum grade point average (GPA) requirements described in the University Policies, the Energy Engineering entrance-to-major requirement must also be completed with a minimum grade of C: MATH 140 GQ(4)[1].

Integrated B.S. in Energy Engineering (ENENG) and M.S. in Energy and Mineral Engineering (EME)

The integrated undergraduate-graduate (IUG) program between the Energy Engineering undergraduate program and the Energy and Mineral Engineering graduate program enables academically superior and research-focused ENENG undergraduate students to also obtain an M.S. degree in Energy and Mineral Engineering in five years of study. Students should refer to the Energy and Mineral Engineering graduate program in the Graduate Program Bulletin for the IUG admission and degree requirements.
(http://bulletins.psu.edu/bulletins/whitebook/graduate_degree_programs.cfm?letter=E&program=grad_eme.htm)

For the B.S. in Energy Engineering, a minimum of 131 credits is required. This baccalaureate program in Energy Engineering is accredited by the Engineering Accreditation Commission of ABET, Inc., www.abet.org.

GENERAL EDUCATION: 45 credits

(30 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)

(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:

(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in GENERAL EDUCATION course selection)

WRITING ACROSS THE CURRICULUM:

(Included in REQUIREMENTS FOR THE MAJOR)

REQUIREMENTS FOR THE MAJOR: 116 credits

(This includes 30 credits of General Education courses; 3 credits of GH courses; 9 credits of GN courses; 6 credits of GQ courses; 3 credits of GS courses; 9 credits of GWS courses.)

PRESCRIBED COURSES (84 credits)

CHEM 110 GN(3), CHEM 111 GN(1), CHEM 112 GN(3), EMSC 100 GWS(3)[88], MATH 140 GQ(4)[11], MATH 141 GQ(4), PHYS 211 GN(4) (Sem: 1-2)

EE 211(3), MATH 231(2), MATH 251(4), PHIL 103 GH(3), PHYS 212 GN(4) (Sem: 3-4)

EGEE 12(1), EGEE 302(3)[11], EGEE 304(3)[11], EGEE 411(3)[11], EGEE 430(3)[11], EGEE 438(3)[11], EME 301(3)[11], EME 303(3)[11], FSC 431(3), MATSE 201(3) (Sem: 5-6)

ENGL 202C GWS(3), EGEE 437(3)[11], EGEE 441(3)[11], EGEE 451(3)[11], EGEE 464(3)[11], FSC 432(3) (Sem: 7-8)

ADDITIONAL COURSES (17 credits)

EBF 200 GS(3) or ECON 102 GS(3) or ECON 014 GS(3) (Sem: 1-2)

ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)

CHEM 202(3) or CHEM 210(3) (Sem: 3-4)

CMPSC 200 GQ(3) or CMPSC 201 GQ(3) or CMPSC 202 GQ(3) (Sem: 3-4)

EME 460(3) or IE 302(3) (Sem: 7-8)

EGEE 494(2)[11] or EGEE 295/395/495(2)[11] (Sem: 5-8)

SUPPORTING COURSES AND RELATED AREAS (15 credits)

Select 3 credits of EGEE electives from an approved list in consultation with an adviser.

Select 6 credits of professional courses from an approved list in consultation with an adviser. Other substitutions outside the approved list must be approved by petition.

Select 6 credits of technical electives from a broad list of energy related courses across colleges at Penn State. A list of suggested courses from energy-related departments at Penn State is provided. (Students may apply 6 credits of ROTC to some of the elective choices.) (Sem: 7-8)

Course Substitutions for the Integrated B.S. in Energy Engineering (ENENG) and M.S. in Energy and Mineral Engineering (EME)

As many as twelve of the credits required for the master's degree may be applied to both the B.S. and M.S. degrees. A minimum of six credits counted for both the B.S. and M.S. degrees must be at the 500-level. Thesis and culminating/capstone experience credits may not be double counted. The undergraduate degree program officer will determine the specific undergraduate required courses for which the 500-level courses may be used to substitute to meet institutional and accreditation requirements.

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[88] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Summer Session 2014

Blue Sheet Item #: 43-01-025

Review Date: 08/19/2014

EM

Environmental Systems Engineering

University Park, College of Earth and Mineral Sciences (ENVSE)

PROFESSOR WILLIAM GROVES, *Undergraduate Program Officer*

It is an interdisciplinary program with two options. One option is Environmental Systems Engineering and it is concerned with the impact of industrial activities on the environment and the choice of cost-effective remediation strategies. The other option is Environmental Health and Safety Engineering and it is concerned with safe and healthful design of industrial systems such that workers are protected from potentially high risk exposures associated with today's industries. The program is unique as it is designed to address critical environmental, safety and health problems of the basic industries such as those involved in the extraction, conversion, and utilization of energy and mineral resources. The courses are sequenced so that students acquire an appropriate blend of theory, applications, and design and are equipped with the fundamentals necessary to maintain lifelong professional growth. Graduates are prepared to enter both the private and public sectors as environmental systems engineers or health and safety engineers or to pursue further education at the graduate level.

During the first two years, the program shares many common features (e.g., mathematics, chemistry, physics, and engineering mechanics) with other more traditional engineering disciplines. Students then take a series of special courses that introduce engineering concepts in the extractive and process industries. Process engineering and a variety of solid-solid, solid-fluid, and fluid-fluid separations play a major and often dominant role in the prevention and/or remediation of environmental damage or the prevention of health and safety hazards resulting from industrial activity.

Students then specialize in the particular problems associated with air, land, or water, environmental health and safety engineering or select a hybrid program. Specialization is accomplished through a combination of additional designated courses and selection from an extensive list of relevant elective courses. The curriculum is structured so as to integrate design concepts into the various subject areas covered in the program.

The human, societal, economic, ethical, and regulatory aspects of the industrial impact on the environment and on the workers themselves are addressed through a combination of specific courses and components of other more general courses. This aspect of the program is designed to provide students with a deeper understanding, both of the impact of environmental degradation on society and of the effects on industrial activity of society's demands for protection of workers and the environment. The program culminates with the capstone design course, which is an integrated, problem-based, multi-faceted project in which students, working in a team setting, utilize fundamental concepts to design an environmental remediation system or an environmental health and safety protection system (or incorporate these design requirements into other associated designs).

The integration of knowledge and skills acquired during the course of study in the Environmental Systems Engineering program provides graduates with the following student outcomes:

- An ability to apply knowledge of mathematics, science, and engineering
- An ability to design and conduct experiments, as well as to analyze and interpret data
- An ability to design a system, component, or process to meet desired needs
- An ability to function on multi-disciplinary teams
- An ability to identify, formulate, and solve engineering problems
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- The broad education necessary to understand the impact of engineering solutions in a global and societal context
- A recognition of the need for and an ability to engage in life-long learning
- A knowledge of contemporary issues
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- An ability to integrate knowledge and minimize environmental impacts in resource recovery and the process industries

Environmental Systems Engineering Program Educational Objectives:

Our graduates will

Enter the private or public sectors as environmental systems engineers to solve a broad range of environmental or health and safety problems associated with the resource recovery and general and process industries or pursue an advanced degree.

Address critical environmental or health and safety problems of the basic industries, especially those involved with the extraction, conversion, and utilization of energy and mineral resources; design effective and economic engineering systems to alleviate such problems, individually and in a team setting; and communicate the results effectively.

Determine the impact of environmental pollution control on the viability of industrial operations, including health and safety, social, and ethical aspects, and an awareness of environmental regulations; evaluate novel strategies for minimizing pollution control costs in the process industries.

Recognize the need to maintain professional competency and the value of life-long learning.

Entrance to Major Requirements:

In addition to the minimum grade point average (GPA) requirements described in the University Policies, the Environmental Systems Engineering entrance-to-major requirement must also be completed with a minimum grade of C: MATH 140 GQ(4), MATH 141 GQ(4), PHYS 211 GN(4), and CHEM 110 GN(3).

Integrated B.S. in Environmental Systems Engineering (ENVSE) and M.S. in Energy and Mineral Engineering (EME)

The integrated undergraduate-graduate (IUG) program between the environmental systems engineering undergraduate program and the energy and mineral engineering graduate program enables academically superior and research-focused ENVSE undergraduate students to also obtain an M.S. degree in Energy and Mineral Engineering in five years of study. Students should refer to the Energy and Mineral Engineering graduate program in the Graduate Program Bulletin for the IUG admission and degree requirements.

(http://bulletins.psu.edu/bulletins/whitebook/graduate_degree_programs.cfm?letter=E&program=grad_eme.htm)

For the B.S. in Environmental Systems Engineering, a minimum of 131 credits is required. This baccalaureate program in Environmental Systems Engineering is accredited by the Engineering Accreditation Commission of ABET, Inc.,

www.abet.org."

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits

(27 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)

(See description of General Education in front of *Bulletin*.)

FIRST-YEAR SEMINAR:

(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in GENERAL EDUCATION course selection)

WRITING ACROSS THE CURRICULUM:

(Included in REQUIREMENTS FOR THE MAJOR)

REQUIREMENTS FOR THE MAJOR: 113-114 credits

(This includes 27 credits of General Education courses; 9 credits of GWS courses; 6 credits of GQ courses; 9 credits of GN courses; 3 credits of GS courses.)

COMMON REQUIREMENTS FOR THE MAJOR (ALL OPTIONS): 97-98 credits

PRESCRIBED COURSES (80 credits)

EMSC 100S GWS(3) [11] (Sem: 1-2)

CHEM 110 GN(3) [11], CHEM 111 GN(1), CHEM 112 GN(3), CHEM 202(3), EMCH 211(3), EMCH 212(3), MATH 140 GQ(4) [11],

MATH 141 GQ(4) [11], MATH 251(4), PHYS 211 GN(4), PHYS 212 GN(4) (Sem: 1-4)

CE 370(3) [11], EME 301(3) [11], EME 303(3) [11] (Sem: 3-6)

ENGL 202C GWS(3) [11], GEOSC 452(3), MNPR 301(3) [11] (Sem: 5-6)

EME 460(3), ENVSE 404(3), ENVSE 406(3), ENVSE 427(3) [11], ENVSE 450(3), ENVSE 470(3), ENVSE 480(3), MNG 401(1),

PNG 411(1) (Sem: 5-8)

ADDITIONAL COURSES (11-12 credits)

ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)

CMPSC 201 GQ(3) or CMPSC 202 GQ(3), or CMPSC 203 GQ(4) (Sem: 3-4)

MATH 220 GQ(2) or MATH 231(2) (Sem: 3-4)

GEOSC 1(3) [11] or GEOSC 71(3) [11] (Sem: 3-6)

SUPPORTING COURSES AND RELATED AREAS (6 credits)

Select 6 credits in consultation with adviser (Sem: 7-8) [2]

REQUIREMENTS FOR THE OPTION: 16 credits

ENVIRONMENTAL SYSTEMS ENGINEERING OPTION: (16 credits)

PRESCRIBED COURSES (10 credits)

GEOG 30 GS;IL(3), MICRB 106 GN(3) (Sem: 1-4)

EGEE 470(3), ENVSE 412(1) (Sem: 5-6)

ADDITIONAL COURSES (6 credits)

ENVSE 408(3), SOILS 401(3), or METEO 455(3) (Sem: 7-8)

METEO 454(3), MNPR 401(3), or MNPR 426(3) (Sem: 7-8)

ENVIRONMENTAL HEALTH AND SAFETY ENGINEERING OPTION: (16 credits)

PRESCRIBED COURSES (16 credits)

BIOL 141 GN(3), PSYCH 100 GS(3) (Sem: 1-4)

ENVSE 440(3) (Sem: 5-6)

ENVSE 400(3), ENVSE 457(3), ENVSE 458(1) (Sem: 7-8)

Integrated B.S. in Environmental Systems Engineering (ENVSE) and M.S. in Energy and Mineral Engineering (EME) Course Substitutions

As many as twelve of the credits required for the master's degree may be applied to both the B.S. and M.S. degrees. A minimum of six credits counted for both the B.S. and M.S. degrees must be at the 500-level. Thesis and culminating/capstone experience credits may not be double counted. The undergraduate degree program officer will determine the specific undergraduate required courses for which the 500-level courses may be used to substitute to meet institutional and accreditation requirements.

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[2] Students who complete Basic ROTC may substitute 6 credits of ROTC for 3 credits of GHA courses and 3 credits of Supporting Courses and Related Areas.

[[88] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Spring Semester 2017

Blue Sheet Item #: 45-04-042A

Review Date: 1/10/2017

UCA Revision #1: 8/4/06

UCA Revision #2: 7/27/07

EM

Geobiology

University Park, College of Earth and Mineral Sciences (GEOBI)

PROFESSOR PETER J. HEANEY, Associate Head for Undergraduate Programs

Geobiology is the interdisciplinary study of the Earth and its biosphere. It embraces the history of life and its interactions with the Earth over geologic time; it also includes study of interactions between living organisms and physical and chemical processes in the modern environment on Earth, and possibly elsewhere in the universe. Thus, geobiology encompasses the fields of paleobiology and paleontology, biogeochemistry, geomicrobiology, and astrobiology. The degree program provides students with a strong background in general science and especially in Geosciences and Biology, with core selections from both disciplines. Students gain practical field experience in the study of the physical environment and ecological properties. The senior thesis provides students with hands-on research experience, as well as an emphasis on data synthesis and the written expression of scientific observations and ideas. Students will be well prepared for advanced studies in this emerging discipline, and for careers in the environmental sciences. Geobiology is critical to the study of environmental quality, global change and environmental-human health interactions, all of which have profound importance in legal, economic, and policy arenas.

For the B.S. degree in Geobiology, a minimum of 121 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits

(21 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)

(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:

(Included in ELECTIVES or GENERAL EDUCATION course selection)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES :

(Included in ELECTIVES, GENERAL EDUCATION course selection, or REQUIREMENTS FOR THE MAJOR)

WRITING ACROSS THE CURRICULUM:

(Included in REQUIREMENTS FOR THE MAJOR)

REQUIREMENTS FOR THE MAJOR: 97 credits

(This includes 21 credits of General Education courses: 9 credits of GN courses, 6 credits of GQ courses, 6 credits of GWS courses.)

PRESCRIBED COURSES (54 credits)

BIOL 110 GN(4)[11], BIOL 220W GN(4)[11], EMSC 100 GWS(3)[71], MATH 140 GQ(4), MATH 141 GQ(4) (Sem: 1-2)

CHEM 110 GN(3), CHEM 111 GN(1), CHEM 112 GN(3), CHEM 113 GN(1), PHYS 211 GN(4), PHYS 213 GN(2) (Sem: 1-4)

GEOSC 1(3) [if GEOSC 1 is not available, GEOSC 20 GN(3) may be substituted] (Sem: 1-6)

GEOSC 201(4), GEOSC 204(4)[1] (Sem: 3-6)

GEOSC 310(4)[1] (Sem: 5-6)

GEOSC 494W(3), GEOSC 496(3) (Sem: 7-8)

ADDITIONAL COURSES (13-14 credits)

ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)

Select 4 credits from GEOSC 202(4), GEOSC 203(4) (Sem: 3-6)

Select 3-4 credits from BIOL 230W GN(4), BIOL 240W GN(4), MICRB 201(3) (Sem: 3-6)

Select 3 credits of field experience from BIOL 444(3), GEOSC 472A(3) (Sem: 5-8)

SUPPORTING COURSES AND RELATED AREAS (29-30 credits)

Select 17-18 credits, in consultation with advisor, supportive of the student's interest. (Students may apply 6 credits of ROTC) (Sem: 3-8)

Select 12 credits, at least 3 credits from each category, from the approved list of evolution, paleobiology and geology courses and biogeochemistry courses (Sem: 7-8)

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[71] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS or ENGL 202C GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Summer Session 2007

Blue Sheet Item #: 35-01-129

Review Date: 8/29/06

UCA Revision #1: 8/8/06

Department Head Changed: 4/12/05

EM

Geography

University Park, College of Earth and Mineral Sciences (GEOBA)

PROFESSOR CYNTHIA A. BREWER, Head

Penn State's College of Earth and Mineral Sciences offers a strong mix of human, physical, and technical components

that comprise the core of the geography major. Undergraduate degrees in geography are offered in the Bachelor of Science (BS) and in the Bachelor of Arts (BA). Both programs offer an integrated course of study in which students learn fundamental concepts in physical and human geography while developing technical proficiency.

The Bachelor of Arts (BA) stresses the social and behavioral aspects of geography; the Bachelor of Science (BS) major stresses the discipline's environmental and technical perspectives. Both majors provide training in descriptive and analytical skills such as mapping and spatial analysis. Substantive course work in the Bachelor of Arts major focuses on the ways people have arranged themselves and their economic, social and political activities on the surface of the Earth. Combining geography with other areas of study allows students to choose from a broad range of topics in order to suit their individual interests. The BA Geography major is especially appropriate for students seeking a deeper understanding of the human experience and for students intending to pursue post-graduate work in geography or related disciplines.

Bachelor's degree program graduates may find employment in federal, state, and local administrative and planning agencies or in private firms that specialize in marketing and environmental research. Geographers make careers doing planning, environmental consulting, policy analysis, demographics, cartography, remote sensing, and geovisualization. They work for government agencies, non-profit and educational institutions, and industry.

Those students seeking a Bachelor of Arts degree in Geography may choose one of three areas of concentration:

GENERAL OPTION: This option is designed to serve the needs of students who want to learn about the various topics and perspectives that comprise the discipline of geography, with emphasis on social and behavioral components. The General option is appropriate both for students who intend to pursue postgraduate degrees and for students who want to emphasize a topic for which no option exists.

HUMAN GEOGRAPHY OPTION: This option offers a program for students interested in a well-rounded education in geography that stresses the social and behavioral aspects of the discipline, including economic geography and political economy; urban/regional development and planning; and cultural/historical geography. The Human Geography option is appropriate both for students who intend to pursue postgraduate degrees and for students who wish to enter careers related to planning, policy, and development.

NATURE-SOCIETY GEOGRAPHY OPTION: This option offers a program for students interested in the interactions between people and their environment that emphasized the complex linkages and multi-scalar processes between the biophysical environment and human societies. The Nature-Society Geography option is appropriate both for students who intend to pursue postgraduate degrees and for students who wish to enter careers related to environmental governance, human dimensions of global change, including climate change, livelihood and ecological sustainability, and ecosystem service provision.

For the B.A. degree in Geography, a minimum of 120 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits
(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:
(Included in ELECTIVES or GENERAL EDUCATION course selection)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:
(Included in ELECTIVES, GENERAL EDUCATION course selection, or REQUIREMENTS FOR THE MAJOR)

WRITING ACROSS THE CURRICULUM:
(Included in ELECTIVES, GENERAL EDUCATION course selection, or REQUIREMENTS FOR THE MAJOR)

ELECTIVES: 9 credits

BACHELOR OF ARTS DEGREE REQUIREMENTS: 24 credits
(3 of these 24 credits are included in the REQUIREMENTS FOR THE MAJOR, GENERAL EDUCATION, or ELECTIVES and 0-12 credits are included in ELECTIVES if foreign language proficiency is demonstrated by examination.)
(See description of Bachelor of Arts Degree Requirements in this bulletin.)

REQUIREMENTS FOR THE MAJOR: 52 credits^[1]
(This includes 10 credits of General Education courses: 4 credits of GQ courses; 6 credits of GWS courses.)

COMMON REQUIREMENTS FOR THE MAJOR (ALL OPTIONS): 31 credits

PRESCRIBED COURSES (25 credits)
EMSC 100 GWS(3)^[71] (Sem: 1-2)
GEOG 10 GN(3), GEOG 20 GS;US;IL(3), GEOG 30 GS;IL(3), GEOG 160 GS(3), STAT 200 GQ(4) (Sem: 1-4)
GEOG 301(3), GEOG 364(3) (Sem: 5-6)

ADDITIONAL COURSES (6 credits)
ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)
Select 3 credits from GEOG 493(3), GEOG 494(3), or GEOG 495(3) (Sem: 5-8)

REQUIREMENTS FOR THE OPTION: 21 credits

GENERAL OPTION: (21 credits)

ADDITIONAL COURSES (21 credits)

PHYSICAL GEOGRAPHY
Select 3 credits from GEOG 110 GN(3), GEOG 111 GN(3), GEOG 115 GN(3), GEOG 310(3), GEOG 311(3), GEOG 313(3), or GEOG 333(3) (Sem: 3-6)
Select 3 credits from GEOG 411(3), GEOG 411W(3), GEOG 412(3), or GEOG 417(3) (Sem: 5-8)

HUMAN GEOGRAPHY

Select 3 credits from GEOG 120 GS;US;IL(3), GEOG 122 GH;US(3), GEOG 123 GS;IL(3), GEOG 124 GS;IL(3), GEOG 126 GS;US;IL(3), GEOG 128 GS;IL(3), or GEOG 130 GS(3) (Sem: 3-6)
Select 3 credits from GEOG 420 US;IL(3), GEOG 423 US(3), GEOG 424 US;IL(3), GEOG 425 US(3), GEOG 426 US;IL(3), GEOG 427 US;IL(3), GEOG 428 US(3), GEOG 429 US;IL(3) (Sem: 5-8)

NATURE-SOCIETY GEOGRAPHY

Select 3 credits from GEOG 430(3), GEOG 431(3), GEOG 434(3), GEOG 436(3), GEOG 438(3), GEOG 439(3), GEOG 444(3) (Sem: 5-8)

GEOGRAPHIC INFORMATION SCIENCE

Select 3 credits from GEOG 361(3), GEOG 362(3), GEOG 363(3), GEOG 364(3) (Sem: 3-6)
Select 3 credits from GEOG 461(3), GEOG 463(3), GEOG 464(3), GEOG 467(3), GEOG 468(3) (Sem: 5-8)

HUMAN GEOGRAPHY OPTION: (21 credits)

ADDITIONAL COURSES (21 credits)

Select 9 credits from GEOG 120 GS;US;IL(3), GEOG 122 GH;US(3), GEOG 123 GS;IL(3), GEOG 124 GS;IL(3), GEOG 126 GS;US;IL(3), GEOG 128 GS;IL(3), or GEOG 130 GS(3) (Sem: 3-6)
Select 12 credits from GEOG 420 US;IL(3), GEOG 423 US(3), GEOG 424 US;IL(3), GEOG 425 US(3), GEOG 426 US;IL(3), GEOG 427 US;IL(3), GEOG 428 US(3), or GEOG 429 US(3) (Sem: 5-8)

NATURE-SOCIETY GEOGRAPHY OPTION: (21 credits)

PRESCRIBED COURSES (9 credits)

GEOG 130 GS(3), GEOG 333(3) (Sem: 3-6)
GEOG 430(3) (Sem: 5-8)

ADDITIONAL COURSES (12 credits)

Select 12 credits from GEOG 431(3), GEOG 434(3), GEOG 436(3), GEOG 438(3), GEOG 439(3), GEOG 444(3) (Sem: 5-8)

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[71] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS or ENGL 202C GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Fall Semester 2011

Blue Sheet Item #: 40-02-003

Review Date: 09/27/2011

EM (Transferred from the College of the Liberal Arts--effective FA2006)

Department head updated: 8/10/15

Geography

University Park, College of Earth and Mineral Sciences (GEOBS)

PROFESSOR CYNTHIA A. BREWER, *Head*

Penn State's College of Earth and Mineral Sciences offers a strong mix of human, physical, and technical components that comprise the core of the geography major. Combining geography with other areas of study allows students to choose from a broad range of topics in order to suit their individual interests. Undergraduate degrees in geography are offered in the Bachelor of Science (BS) and in the Bachelor of Arts (BA). Both programs offer an integrated course of study in which students learn fundamental concepts in physical and human geography while developing technical proficiency.

The Bachelor of Science (BS) major stresses the discipline's environmental perspectives, while the Bachelor of Arts (BA) stresses the social and behavioral aspects of geography. Both majors provide training in descriptive and analytical skills such as map reading, cartography, and statistics. Substantive course work in the Bachelor of Science major focuses on the ways people use environmental resources and how they arrange themselves and their economic, social, and political activities on the Earth's surface. The Geography major can provide preparation for a career in business, industry, or government. Geographers with bachelor's degrees are currently being placed in federal, state, and local administrative and planning agencies and in private firms that specialize in planning and development or in environmental and socioeconomic analysis.

Those students seeking a Bachelor of Science degree have a choice of one of three areas of concentration:

GENERAL OPTION: This option is designed to serve the needs of students who want to learn about the various topics and perspectives that comprise the discipline of geography. The General option is appropriate both for students who intend to pursue postgraduate degrees and for students who want to emphasize a topic for which no option exists.

GEOGRAPHIC INFORMATION SCIENCE OPTION: This option helps prepare students for entry-level positions in public and private mapping/remote sensing agencies and firms. The student may specialize in one or all of the areas covered in the option. This option is appropriate for students intending to pursue advanced degrees with specialization in these fields.

PHYSICAL/ENVIRONMENTAL GEOGRAPHY OPTION: This option is appropriate for students who want a broad understanding of the earth and environmental sciences in preparation for careers in industry, commerce, and government. The option is designed to develop competence in description, analysis, explanation, and management of problems arising from human use of natural resources and natural systems.

Geography courses satisfying the United States Cultures and International Cultures requirement: GEOG 20 GS;US;IL(3),

GEOG 40 GS;IL(3), GEOG 120 GS;US;IL(3), GEOG 123 GS;IL(3), GEOG 124 GS;IL(3), GEOG 126 GS;US;IL(3), GEOG 128 GS;IL(3), GEOG 420 US;IL(3), GEOG 424 US;IL(3), GEOG 426 IL(3), and GEOG 427 US;IL(3).

Geography courses satisfying the Writing requirement: GEOG 310(3), GEOG 411W(3), GEOG 412(3), GEOG 420 US(3), GEOG 423 US;IL(3), GEOG 424 US;IL(3), GEOG 438(3), and GEOG 461(3). All students must satisfactorily complete at least one writing-intensive course in Geography.

For the B.S. degree in Geography, a minimum of 120 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits

(12 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)

(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:

(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in ELECTIVES, GENERAL EDUCATION course selection, or REQUIREMENTS FOR THE MAJOR)

WRITING ACROSS THE CURRICULUM:

(Included in REQUIREMENTS FOR THE MAJOR)

ELECTIVES: 10 credits

REQUIREMENTS FOR THE MAJOR: 77 credits

(This includes 12 credits of General Education courses: 6 credits of GQ courses; 6 credits of GWS courses.)

COMMON REQUIREMENTS FOR THE MAJOR (ALL OPTIONS): 47 credits

PRESCRIBED COURSES (28 credits)

EMSC 100 GWS(3)[11] (Sem: 1-2)

GEOG 10 GN(3)[11], GEOG 20 GS;US;IL(3)[11], GEOG 30 GS;IL(3)[11], GEOG 130 GS(3)[11], GEOG 160 GS(3)[11], STAT 200 GQ(4) (Sem: 1-4)

GEOG 301(3)[11], GEOG 364(3)[11] (Sem: 5-6)

ADDITIONAL COURSES (19 credits)

ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)

Select 4 credits from: MATH 83 GQ(4), MATH 110 GQ(4), or MATH 140 GQ(4) (Sem: 1-4)

PHYSICAL GEOGRAPHY

Select 3 credits from: GEOG 110 GN(3)[11], GEOG 111 GN(3)[11], or GEOG 115 GN(3)[11] (Sem: 3-6)

HUMAN GEOGRAPHY

Select 3 credits from: GEOG 120 GS;US;IL(3)[11], GEOG 122 GH;US(3)[11], GEOG 123 GS;IL(3)[11], GEOG 124 GS;IL(3)[11], GEOG 126 GS;US;IL(3)[11], or GEOG 128 GS;IL(3)[11] (Sem: 3-6)

GEOGRAPHIC INFORMATION SCIENCE

Select 3 credits from GEOG 361(3)[11], GEOG 362(3)[11], or GEOG 363(3)[11] (Sem: 3-6)

PROFESSIONALISM

Select 3 credits from : GEOG 493(3)[11], GEOG 494(3)[11], GEOG 495(3)[11], GEOG 495B(3)[11], or GEOG 495G(3)[11] (Sem: 5-8)

REQUIREMENTS FOR THE OPTION: 30 credits [11]

GENERAL OPTION: (30 credits) [11]

ADDITIONAL COURSES (30 credits)

Select 12 credits of 400-level courses from the following categories in the option

PHYSICAL GEOGRAPHY

Select 3 credits from GEOG 310(3), GEOG 311(3), GEOG 313(3), GEOG 411(3), GEOG 411W(3), GEOG 412(3), or GEOG 417(3) (Sem: 5-8)

HUMAN GEOGRAPHY

Select 3 credits from GEOG 420 US;IL(3), GEOG 423 US(3), GEOG 424 US;IL(3), GEOG 425(3), GEOG 426 US;IL(3), GEOG 427 U;IL(3), GEOG 428 US(3), or GEOG 429 US;IL(3) (Sem: 5-8)

NATURE-SOCIETY GEOGRAPHY

Select 3 credits from GEOG 333(3), GEOG 430(3), GEOG 434(3), GEOG 436(3), GEOG 438(3), GEOG 439(3), or GEOG 444(3) (Sem: 5-8)

GEOGRAPHIC INFORMATION SCIENCE

Select 3 credits from GEOG 361(3), GEOG 362(3), or GEOG 363(3) (Sem: 3-6)

Select 15 credits from all remaining 300- and 400-level GEOG courses (Sem: 5-8)

GEOGRAPHIC INFORMATION SCIENCE OPTION: (30 credits)[11]

PRESCRIBED COURSES (12 credits)

GEOG 361(3), GEOG 362(3), GEOG 363(3) (Sem: 3-6)

GEOG 464(3) (Sem: 5-8)

ADDITIONAL COURSES (18 credits)

Select 18 credits from GEOG 313(3), GEOG 417(3), GEOG 461, GEOG 463(3), GEOG 467(3), GEOG 468(3), GEOG 485(3), or GEOG 495G(3) (Sem: 5-8)

PHYSICAL/ENVIRONMENTAL GEOGRAPHY OPTION: (30 credits) [11]

PRESCRIBED COURSES (3 credits)

GEOG 313(3) (Sem: 5-8)

ADDITIONAL COURSES (27 credits)

Select 6 credits from GEOG 110 GN(3), GEOG 111 GN(3), or GEOG 115 GN(3) (Sem: 3-6)

Select 9 credits from GEOG 310W(30), GEOG 311(3), GEOG 333(3), or GEOSC 340(3) (Sem: 5-8)

Select 12 credits from GEOG 411(3), GEOG 412(3), GEOG 417(3), GEOG 430(3), GEOG 431(3), GEOG 434(3), GEOG 438(3), or GEOG 493(3) (Sem: 5-8)

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[71] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS or ENGL 202C GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Fall Semester 2011

Blue Sheet Item #: 40-02-004

Review Date: 09/27/2011

EM

Department head: 8/10/15

Geosciences

University Park, College of Earth and Mineral Sciences (GSCBA)

PROFESSOR PETER J. HEANEY, *Associate Head for Undergraduate Programs*

The geosciences are concerned with understanding earth processes and the evolutionary history of the Earth. Geoscientists work to discover and develop natural resources such as groundwater, metals, and energy sources; to solve technology-generated environmental problems such as acid mine drainage and waste disposal; to predict geological events, such as the occurrence of earthquakes and volcanism; and to solve fundamental questions concerning the origin and evolution of Earth and life. The Bachelor of Arts degree program stresses data collection; investigation, analysis and synthesis of information related to complex natural problems; rigor of thought and clarity of oral and written expression. The B.A. provides a basic education in geosciences, and is designed for students who wish to prepare themselves for careers that interface among science, social science, and business. Examples of these careers include environmental law, national and international planning or resource management, and K-12 teaching.

For the B.A. degree in Geosciences, a minimum of 120 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits

(21 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)
(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:

(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in GENERAL EDUCATION course selection or REQUIREMENTS FOR THE MAJOR)

WRITING ACROSS THE CURRICULUM:

(Included in REQUIREMENTS FOR THE MAJOR)

BACHELOR OF ARTS DEGREE REQUIREMENTS: 24 credits

(3 of these 24 credits are included in the REQUIREMENTS FOR THE MAJOR, GENERAL EDUCATION, or ELECTIVES and 0-12 credits are included in ELECTIVES if foreign language proficiency is demonstrated by examination.)

(See description of Bachelor of Arts Degree Requirements in this bulletin.)

REQUIREMENTS FOR THE MAJOR: 72 credits

(This includes 21 credits of General Education courses: 9 credits of GN courses; 6 credits of GQ courses; 6 credits of GWS courses.)

PRESCRIBED COURSES (10 credits)

EMSC 100 GWS(3)[71] (Sem: 1-2)

GEOSC 1(3)[11] [if GEOSC 1 is not available, GEOSC 20 GN(3) may be substituted] (Sem: 1-6)

GEOSC 201(4)[11] (Sem: 3-6)

ADDITIONAL COURSES (48-51 credits)

ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)

MATH 140 GQ(4) or MATH 110 GQ(4) (Sem: 1-2)

GEOSC 310(4)[11] or GEOSC 320(3)[11] (Sem: 3-6)

GEOSC 202(4), GEOSC 203(4), or GEOSC 204(4) (Sem: 5-8)

Select 20 credits--two of the following sequences for 8 credits each and the third sequence for 4 credits:

-BIOL 110 GN(4), BIOL 220W GN(4) (Sem: 1-4)

-CHEM 110 GN(3), CHEM 111 GN(1), CHEM 112 GN(3), CHEM 113 GN(1) (Sem: 1-4)

-PHYS 250 GN(4), PHYS 251 GN(4) (Sem: 1-4)

Note: PHYS 211 GN(4), PHYS 212 GN(4), PHYS 213 GN(2), PHYS 214 GN(2) may substitute for up to 8 credits in Physics for students with MATH 140 GQ(4), MATH 141 GQ(4).

Select 2-4 credits of advanced mathematics in consultation with an adviser; list includes MATH 111 GQ(2), MATH 141

GQ(4), STAT 200 GQ(4), STAT 250 GQ(3) (Sem: 2-6)
Select 6 credits from 300- and 400-level GEOSC courses (Sem: 5-8)
Select 3 credits of appropriate field/laboratory experience in consultation with adviser (Sem: 6-8)
Select 3 credits of writing-intensive courses from within Earth and Mineral Sciences to include, but not limited to: GEOG 412(3), GEOG 310(3), GEOSC 402(3), GEOSC 470(1-6), METEO 471(3) (Sem: 6-8)

SUPPORTING COURSES AND RELATED AREAS (11-14 credits)

Select 11-14 credits in consultation with adviser.
(Students may apply 6 credits of ROTC) (Sem: 3-8)

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[71] The following substitutions are allowed for students attending campuses where the indicated course is not offered:
CAS 100 GWS or ENGL 202C GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Summer Session 2000

Blue Sheet Item #: 28-05-014

Review Date: 10/8/02

UCA Revision #1: 8/8/06

EM

Geosciences

University Park, College of Earth and Mineral Sciences (GSCBS)

PROFESSOR PETER J. HEANEY, *Associate Head for Undergraduate Programs*

The geosciences are concerned with understanding earth processes and the evolutionary history of the Earth. Geoscientists work to discover and develop natural resources such as groundwater, metals, and energy sources; to solve technology-generated environmental problems such as acid mine drainage and waste disposal; to predict geological events, such as the occurrence of earthquakes and volcanism; and to solve fundamental questions concerning the origin and evolution of Earth and life. Our degree programs stress data collection; investigation, analysis and synthesis of information related to complex natural problems; and rigor of thought and clarity of oral and written expression. The B.S. provides a broad foundation in the physical and natural sciences for students who seek immediate employment or post-graduate education in several areas of the geosciences. Examples of careers include the petroleum and mining industries; local or federal resource management; water resources, treatment and management; energy and environmental industries; and academia. A senior thesis involving independent research is required of all students.

Entry to Major Requirements:

In addition to the minimum grade point average (GPA) requirements described in the University Policies, the Geosciences entrance-to-major requirement must also be completed with a minimum grade of C: MATH 140 GQ(4).

GENERAL OPTION: This option is designed to provide sufficient flexibility so that the student has the opportunity to prepare for graduate school by focusing on specialized areas in the geosciences. The option's flexibility also permits students to develop a broad background in the geosciences in preparation for post-graduate majors that require breadth, such as environmental law.

HYDROGEOLOGY OPTION: This option helps prepare the student for entry-level positions in environmental agencies and firms where a specialized knowledge of groundwater and related areas is required. The option is also appropriate for students wishing to pursue an advanced degree in the area of hydrogeology.

For the B.S. degree in Geosciences, a minimum of 121 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem:1-2)

GENERAL EDUCATION: 45 credits
(21 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)
(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:
(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:
(Included in GENERAL EDUCATION course selection)

WRITING ACROSS THE CURRICULUM:
(Included in REQUIREMENTS FOR THE MAJOR)

REQUIREMENTS FOR THE MAJOR: 97 credits
(This includes 21 credits of General Education courses: 9 credits of GN courses, 6 credits of GQ courses, 6 credits of GWS courses.)

COMMON REQUIREMENTS FOR THE MAJOR (ALL OPTIONS): 69 credits

PRESCRIBED COURSES (66 credits)

BIOL 110 GN(4), EMSC 100 GWS(3)[71], MATH 140 GQ(4)[1], MATH 141 GQ(4) (Sem: 1-2)
CHEM 110 GN(3), CHEM 111 GN(1), CHEM 112 GN(3), CHEM 113 GN(1), PHYS 211 GN(4), PHYS 213 GN(2) (Sem: 1-4)
GEOSC 1(3) [if GEOSC 1 is not available, GEOSC 20 GN(3) may be substituted] (Sem: 1-6)

GEOSC 201(4) [11], GEOSC 202(4) [11], GEOSC 204(4) (Sem: 3-6)
GEOSC 203(4) [11], GEOSC 310(4) [11], GEOSC 465(4) [11], GEOSC 472A(3), GEOSC 472B(3) (Sem: 5-6)
GEOSC 494W(3), GEOSC 496(1) (Sem: 7-8)

ADDITIONAL COURSES (3 credits)
ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)

REQUIREMENTS FOR THE OPTION: 28 credits

GENERAL OPTION: (28 credits)

ADDITIONAL COURSES (14 credits)
Select 14 credits from 300- and 400-level GEOSC courses: GEOSC 303(3), GEOSC 340(3), GEOSC 402(3), GEOSC 416(3), GEOSC 421(3), GEOSC 422(3), GEOSC 423(4), GEOSC 424(3), GEOSC 426(3), GEOSC 434(3), GEOSC 439(3), GEOSC 440(3), GEOSC 451(3), GEOSC 452(3), GEOSC 454(3), GEOSC 461(3), GEOSC 470(3), GEOSC 471(3), GEOSC 489(4) (Sem: 5-8)

SUPPORTING COURSES AND RELATED AREAS (14 credits)
Select at least 2 credits in physics from approved departmental list (Sem: 1-4)
Select 3 credits of computer science, mathematics [above the level of MATH 141 GQ(4)], or statistics (Sem: 3-6)
Select 9 credits, in consultation with adviser, supportive of the student's interest (Students may apply 6 credits of ROTC.) (Sem: 3-8)

HYDROGEOLOGY OPTION: (28 credits)

PRESCRIBED COURSE (3 credits)
GEOSC 452(3) (Sem: 5-8)

ADDITIONAL COURSES (15 credits)
Select 3 credits from CMPSC 201 GQ(3), CMPSC 202 GQ(3), CMPSC 203 GQ(4), STAT 250 GQ(3) [if STAT 250 is not available, STAT 200 GQ(4) may be substituted] (Sem: 3-8)
Select 3 credits from ASM 327(3), ERM 450(3), SOILS 101 GN(3) (Sem: 5-8)
Select 9 credits from A and B. Students must select at least 3 credits from A and 3 credits from B.
A. CHEM 202(3), CHEM 450(3), ERM 433(3), GEOSC 413(3), GEOSC 419(3) (Sem: 3-8)
B. ENVSE 408(3), GEOG 362(3), GEOSC 340(3), GEOSC 439(3), GEOSC 454(3), GEOSC 483(3) (Sem: 5-8)

SUPPORTING COURSES AND RELATED AREAS (10 credits)
Select at least 2 credits in Physics from approved departmental list (Sem: 1-4)
Select 8 credits, in consultation with advisor, supportive of the student's interest. (Students may apply 6 credits of ROTC) (Sem: 3-8)

Integrated B.S./M.S. Program in Geosciences

The Department of Geosciences offers an integrated B.S./MS. Program that is designed to allow academically superior students to obtain both the B.S. and the M.S. degree in Geosciences within 5 years of study. Students who wish to complete the Integrated B.S./M.S. Program in Geosciences must apply for admission to the Graduate School and the Integrated B.S/M.S program by the end of their junior year.

During the first three years, the student follows the course scheduling of one of the options in Geosciences; however, if a student intends to enter the Integrated B.S./M.S. program, he/she would be encouraged to take, wherever appropriate, upper level classes. By the end of the junior year, the student normally would apply for admission to the program. A decision of acceptance would be made prior to the beginning of the senior year and a M.S. Advising Committee appointed. During the senior year, the student would follow the scheduling of the B.S. Geosciences option he/she has selected, with an emphasis on completing 500-level coursework wherever appropriate. In place of the Senior Thesis, the student will complete a M.S. Thesis

During the fifth year the student will take courses fulfilling the departmental M.S. degree requirements and complete the M.S. Thesis.

Admissions Requirements

Students who wish to complete the Integrated B.S./M.S. Program in Geosciences must apply for admission to the Graduate School and the Integrated B.S./M.S program by the end of their junior year. Typical tests scores of students admitted to the Geosciences Graduate Program are: GPA 3.5, and GRE's Verbal 570 and Quantitative 700. Three letters of recommendation by faculty members for admission to graduate studies are required. The applications are reviewed by the Admissions Committee of the Geosciences Graduate Program and acted upon by the Associate Head for Graduate Programs.

The details of the program requirements can be found in the *Graduate Degree Programs Bulletin*.

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[71] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS or ENGL 202C GWS can be substituted for EM SC 100S GWS.

Last Revised by the Department: Fall Semester 2013 (GSCBS); Summer Session 2005 (Integrated B.S./M.S.)

Blue Sheet Item #: 42-04-019 (GSCBS); 33-04-165 (Integrated B.S./M.S.)

Review Date: 01/14/2014

UCA Revision #1: 8/8/06
UCA Revision #2: 7/27/07

EM

Liberal Arts and Earth and Mineral Sciences Concurrent Degree Program

Liberal Arts and Engineering Concurrent Degree Program

These programs require ten semesters of study, concurrently in the College of the Liberal Arts (during which the student completes 70 credits in General Education and Bachelor of Arts requirements and 33 to 37 basic engineering or science requirements), and in either the College of Earth and Mineral Sciences or the College of Engineering (during which the student completes the credits required in the selected major in Earth and Mineral Sciences or Engineering).

Upon completion of the program, the B.A. in General Arts and Sciences will be awarded by the College of the Liberal Arts and the B.S. by the College of Earth and Mineral Sciences or the College of Engineering. The majors available in the College of Earth and Mineral Sciences are Environmental Systems Engineering, Geosciences, Mining Engineering, Polymer Science, Mineral Economics, Petroleum and Natural Gas Engineering, Ceramic Science and Engineering, Metals Science and Engineering, or Meteorology. The majors available in the College of Engineering are Aerospace, Agricultural, Chemical, Civil, Electrical, Environmental, Industrial and Management Systems, Mechanical, or Nuclear Engineering, or Engineering Science.[\[44\]](#)

To be eligible for this program, a student must file an application for entrance with the associate dean for undergraduate studies, College of the Liberal Arts, not later than the third semester. Entrance to the program requires that the student satisfy all regular requirements of the College of the Liberal Arts and the College of Earth and Mineral Sciences or the College of Engineering. In addition, special requirements may need to be satisfied when enrollment controls are imposed on programs in any of the colleges because of space limitations. Once a student has met all the requirements for entrance to this program, transfer from the College of the Liberal Arts to the College of Earth and Mineral Sciences or the College of Engineering, with enrollment in one of the majors listed, will be approved automatically at the end of the sixth semester if the student continues to make normal progress toward the concurrent degree and has maintained a cumulative average of 2.00 or higher. Students entering majors in the College of Engineering must complete the following courses with a grade of C or higher: CHEM 110 GN(3) and CHEM 111 GN(1), MATH 140 GQ(4), MATH 141 GQ(4), and PHYS 201 GN(4), and meet the required cumulative grade-point average for the requested engineering major.

Students are advised of the absolute necessity for scheduling classes in exact sequence during the first six semesters of Concurrent Degree study. It is imperative that students obtain, from the Liberal Arts Undergraduate Studies Office, 101 Sparks Building, a copy of the Concurrent Degree requirements worksheet that enumerates the specific course requirements for the two programs for semesters one through six.

Scheduling Recommendation by Semester Standing given like (Sem:1-2)

GENERAL EDUCATION: 45 credits

(15 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)
(See description for General Education in this bulletin.)

FIRST-YEAR SEMINAR:

(Included in GENERAL EDUCATION course selection or REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in GENERAL EDUCATION course selection or REQUIREMENTS FOR THE MAJOR)

WRITING ACROSS THE CURRICULUM:

(Included in GENERAL EDUCATION course selection or REQUIREMENTS FOR THE MAJOR)

BACHELOR OF ARTS DEGREE REQUIREMENTS: 24 credits

(3 of these 24 credits are included in the REQUIREMENTS FOR THE MAJOR, GENERAL EDUCATION, or ELECTIVES and 0-12 credits are included in ELECTIVES if foreign language proficiency is demonstrated by examination.)
(See description of Bachelor of Arts Degree Requirements in this bulletin.)

REQUIREMENTS FOR THE MAJOR: 12 credits

EARTH AND MINERAL SCIENCES OR ENGINEERING COMPONENT: 89-91 credits

(This includes 15 credits of General Education courses: 6 credits of GQ courses and 9 credits of GN courses.)

SEMESTERS ONE THROUGH SIX (33-34 credits)[\[45\]](#)

PRESCRIBED COURSES (27 credits)

CHEM 111 GN(1), CHEM 113 GN(1), MATH 220 GQ(2-3), MATH 230(4), MATH 250(3) (Sem: 1-4)

EG 10(1), EG 11(1) (Sem: 3-4)

PHYS 201 GN(4), PHYS 202 GN(4) (Sem: 3-6)

EMCH 211(3), EMCH 212(3) (Sem: 5-8)

ADDITIONAL COURSES (6-7 credits)

PHYS 203 GN(3) or PHYS 204 GN(4) (Sem: 3-6)

B.S. requirements[\[46\]](#)(3) (Sem: 5-6)

SEMESTERS SEVEN THROUGH TEN (56-57 credits)

Credits required in the selected major in Earth and Mineral Sciences or Engineering (56-57) (Sem: 7-10)

SUPPORTING COURSES AND RELATED AREAS (12 credits)

Select 3 credits from each of the following areas: arts, humanities, science/mathematics, social and behavioral sciences.
(Sem: 9-10)

[44] Enrollment in the Engineering Science program is limited to those students attaining an average of B or higher during their first six semesters and to those specially chosen by the College of Engineering faculty on the basis of evidence that they will benefit from the advanced courses.

[45] Concurrent Degree candidates should consult the individual program requirements in the College of Engineering

and the College of Earth and Mineral Sciences to ascertain which combinations of CHEM, E G, E MCH, MATH, and PHYS are required.

[46] Concurrent Degree candidates should select a course in this category appropriate for the requirements for their program in either Earth and Mineral Sciences or Engineering.

Last Revised by the Department: Summer Session 1991

Blue Sheet Item #: 16-10-030

Review Date: 5/22/08

UCA Revision #1: 8/8/06

46-01-021 Change. Add Entrance Requirements. **Changes** indicated by underlining.

Effective Date: Spring Semester 2018

Materials Science and Engineering

University Park, College of Earth and Mineral Sciences (MATSE)

PROFESSOR GARY L. MESSING, *Head, Department of Materials Science and Engineering*

PROFESSOR R. ALLEN KIMEL, *Associate Head of Undergraduate Studies, Materials Science and Engineering*

Materials, like ceramics, metals, polymers, and composites, are critical to the growth and success of many industries and key to most engineering disciplines. Graduates of Materials Science and Engineering are employed, or proceed to graduate studies, in many fields such as energy, medicine, sustainability, electronics, communications, transportation, aerospace, defense, and infrastructure industries.

The mission of the department is to provide students with a well-rounded engineering education, with specific emphasis on materials science and engineering in order to meet the needs of industry, academia, and government; to conduct research at the frontiers of the field; and to provide an integrating and leadership role to the broad multidisciplinary materials community.

The integration of knowledge and skills acquired during the course of study in the Materials Science and Engineering program provides graduates with the following student outcomes:

- a) Graduates will be able to apply knowledge of mathematics and advanced science and engineering principles to materials systems.
- b) Graduates will be able to design and conduct experiments and to analyze and interpret data.
- c) Graduates will be able to design a process, a microstructure, or a component to satisfy system needs.
- d) Graduates will be able to function on multi-disciplinary teams.
- e) Graduates will be able to identify, formulate, and solve engineering problems.
- f) Graduates will understand professional and ethical responsibility.
- g) Graduates will be able to communicate effectively, both in writing and in speech.
- h) Graduates will possess the broad education necessary to understand the impact of engineering solutions in a global and societal context.
- i) Graduates will recognize the need for, and be able to engage in, lifelong learning.
- j) Graduates will have a knowledge of contemporary issues.
- k) Graduates will be able to use the experimental, analytical, statistical, and computational tools for engineering practice in the materials discipline.
- l) Graduates will be able to apply the fundamental principles underlying and connecting the structure, processing, properties, and performance of materials systems.

The educational objectives of the undergraduate program are embedded into our mission statement. We will provide and maintain a curriculum that will prepare our recent graduates to accomplish the following Program Educational Objectives:

1. Our graduates provide science and engineering leadership in international industrial, governmental, and academic settings, while serving both their profession and the public.
2. Our graduates are innovators in a wide variety of technical fields including, but not limited to, materials, energy, electronics, medicine, communications, transportation, and recreation.
3. Our graduates excel in careers relating to the entire life cycle of materials, from synthesis and processing, through design and development, to manufacturing, performance, reclamation, and recycling.
4. Our graduates engage in lifelong learning activities which enhance their careers and provide flexibility to respond to changing professional and societal needs.

We achieve these objectives by providing a rigorous but flexible curriculum that allows the student to design their degree in materials science and engineering to achieve their specific academic and professional career interests.

In addition to the cutting edge curriculum, we provide many opportunities to strengthen the student's undergraduate studies through research experiences. For example, over 60% of the undergraduates are members of a research group and participate in the extensive materials research programs at Penn State. Further, we provide opportunities for International Internships in Materials, where our students go abroad to perform research at one of the many

internationally recognized partner universities in Europe and Asia.

The B.S. degree in Materials Science and Engineering is accredited by the Engineering Accreditation Commission of ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone: 410.347.7700 or www.abet.org.

Entrance to Major Requirements: In order to be eligible for entrance to the Materials Science and Engineering major, a student must have: 1) Attained at least a 2.00 cumulative grade-point average. 2) Completed CHEM 110 GN(3), CHEM 111 GN(1), CHEM 112 GN(3), CHEM 113 GN(1), MATH 140 GQ(4), MATH 141 GQ(4), MATH 220(2) and PHYS 211(4); earned a grade of C or better in each of these courses; and earned a combined grade point average of at least 2.50 in these courses. (Note: If courses are repeated, only the higher grade will be used in this calculation.)

For the B.S. in Materials Science and Engineering, a minimum of 131 credits is required. This baccalaureate program in Materials Science and Engineering is accredited by the Engineering Accreditation Commission of ABET, Inc., www.abet.org.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION 45 credits

(24 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)

(See description of General Education in front of *Bulletin*. Note: The Accreditation Board for Engineering and Technology (ABET) does not permit the use of skills courses to satisfy the Arts category of General Education.)

FIRST-YEAR SEMINAR:

(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in GENERAL EDUCATION course selection)

WRITING ACROSS THE CURRICULUM:

(Included in REQUIREMENTS FOR THE MAJOR)

REQUIREMENTS FOR THE MAJOR: 110 credits

(This includes 24 credits of General Education courses: 9 credits of GN courses; 6 credits of GQ courses; 9 credits of GWS courses.)

PRESCRIBED COURSES (79 credits)

CHEM 110 GN(3), CHEM 111 GN(1), CHEM 113 GN(1), CHEM 202 GN(3), CMPSC 200 GQ(3), EMSC 100 GWS(3)**[71]**, MATH 140G GQ(4), MATH 141G GQ(4), MATH 220 GQ(2), MATH 231(2), MATH 251(4), MATSE 112 GN(3), PHYS 211 GN(4), PHYS 212 GN(4), IE 424(3) (Sem: 1-4)
MATSE 201(3)**[1]**, MATSE 202(3)**[1]**, MATSE 413 GN(3) (Sem: 3-4)
ENGL 202C GWS(3), MATSE 400(3)**[1]**, MATSE 401(3)**[1]**, MATSE 402(3)**[1]**, MATSE 419(3), MATSE 430(3)**[1]**, MATSE 436(3), MATSE 460(1), MATSE 462(1), MATSE 492(3)**[1]** (Sem: 5-6)

ADDITIONAL COURSES (19 credits)

ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-4)

Select 3 or 6 credits from Synthesis and Processing: MATSE 411(3), MATSE 422(3), MATSE 425(3), MATSE 441(3), MATSE 448(3), MATSE 450(3) (Sem: 6-8)

Select 3 or 6 credits from Structure and Characterization: MATSE 410(3), MATSE 415(3), MATSE 421(3), MATSE 444(3), MATSE 445(3), MATSE 455(3) (Sem: 6-8)

Select 3 or 6 credits from Properties: MATSE 412(3), MATSE 417(3), MATSE 435(3), MATSE 446(3), MATSE 447(3) (Sem: 6-8)

Select 1 credit from Processing Laboratory: MATSE 463(1), MATSE 468(1), MATSE 472(1), MATSE 474(1) (Sem: 7)

Select 3 credits from Senior Capstone Experience: MATSE 493(3) or MATSE 494W(3) (Sem: 7-8)

SUPPORTING COURSE AND RELATED AREAS (12 credits)

Select 12 credits of approved Science or Engineering Elective courses in consultation with advisor (Sem: 6-8)

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[71] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS or ENGL 202C GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Fall Semester 2017

Blue Sheet Item #: 46-01-021

Review Date: 8/22/2017

UCA Revision #1: 8/9/06

UCA Revision #2: 7/30/07

EM

Meteorology and Atmospheric Science

University Park, College of Earth and Mineral Sciences (METEO)

PROFESSOR David Stensrud, *Head of the Department*

Meteorology is a rigorous scientific discipline devoted to the attainment of an increased understanding of the atmosphere and the development of methods for applying that knowledge to practical problems. Although this field is usually associated with weather prediction, it also has significance in environmental, energy, agricultural, oceanic, and hydrological sciences. For students wishing to pursue many of these areas, the department offers several options within the major.

The major requires a solid foundation in mathematics and the physical sciences, and it provides a comprehensive

survey of the fundamentals of atmospheric science. It has sufficient flexibility to permit intensive advanced study in such related areas as mathematics, earth sciences, or engineering. The department has particular strengths in weather analysis and prediction, including forecast uncertainty and severe weather; physical meteorology, including radar meteorology, instrumentation and atmospheric measurements; and applied areas, including atmospheric diffusion, air pollution chemistry, dynamic meteorology, tropical meteorology, climate, weather risk, and remote sensing.

Graduating meteorologists are prepared for professional employment with industry, private consulting firms, government, and the armed forces or for further study toward graduate degrees normally required for research, university, or management positions.

The freshman and sophomore years are largely devoted to preparatory work in science, mathematics, and the liberal arts. The junior and senior years involve a core of basic courses in applied and theoretical topics and a choice of courses offering specialized training. The courses unique to each option are normally taken in the junior and senior years.

Entry to Major Requirements:

In addition to the minimum grade point average (GPA) requirements described in the University Policies, the Meteorology entrance-to-major requirement must also be completed with a minimum grade of C: MATH 140 GQ(4).

ATMOSPHERIC SCIENCE OPTION: This option challenges students to strengthen and broaden their understanding of the physics and chemistry of both the atmosphere and oceans. It helps prepare them for employment in the diverse field of the atmospheric sciences and for graduate study in the atmospheric or related disciplines. Students are encouraged to participate in undergraduate research projects under the supervision of atmospheric and oceanic scientists in the department college.

ENVIRONMENTAL METEOROLOGY OPTION: Environmental Meteorology prepares the student for understanding the impact of the weather and climate on the environment, which is to say the impacts of air and water on natural and human-altered ecosystems. In order to do this, the option establishes links between atmospheric physics and a variety of environmental disciplines pertaining to land, water, soils, and plants. Depending on his/her interests, the student will select courses in the Air Quality and Dispersion, Ecology, Environmental Chemistry, Geographic Information Systems or Hydrology.

GENERAL OPTION: This option has sufficient flexibility to serve the needs of students who wish to pursue topics chosen broadly from subdisciplines of meteorology or from related areas in consultation with the academic adviser. The General option is appropriate both for students who intend to pursue postgraduate degrees and for students who want to emphasize a topic for which no option exists.

WEATHER FORECASTING AND COMMUNICATIONS OPTION: This option prepares students for careers in which their skills as weather forecasters are effectively used in a variety of ways, from science reporting and television broadcasting to web design and computer-based weather graphics production, and developing innovative applications of weather and climate data to industry.

WEATHER RISK MANAGEMENT OPTION: The option combines study of meteorology and atmospheric sciences with training in risk, finance, and quantitative decision-making. Weather affects a wide range of industries, including energy, agriculture, insurance, construction, retail, and transport, among others. Weather and climate variation play central roles in the availability of water resources, the spread of disease, and an array of other processes vital for human welfare. There are, consequently, many organizations that confront risks related to weather, and that have a demand for experts who can help them manage these risks. The option in Weather Risk Management is designed for students who wish to work professionally at this intersection of meteorology and risk management.

For a Meteorology course to serve as a prerequisite for any subsequent prescribed or supporting Meteorology course in the major, a grade of C or better must be earned in the prerequisite course.

For the B.S. degree in Meteorology, a minimum of 121 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits
(23-26 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)
(See description of General Education in front of *Bulletin*.)

FIRST-YEAR SEMINAR:
(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:
(Included in ELECTIVES or GENERAL EDUCATION course selection)

WRITING ACROSS THE CURRICULUM:
(Included in REQUIREMENTS FOR THE MAJOR)

ELECTIVES: 4-9 credits

REQUIREMENTS FOR THE MAJOR: 93-95 credits
(This includes 23-26 credits of General Education courses: 8 credits of GN courses; 6 credits of GQ courses; 0-3 credits of GS courses; 9 credits of GWS courses.)

COMMON REQUIREMENTS FOR THE MAJOR (ALL OPTIONS): 66 credits

PRESCRIBED COURSES (47 credits)
CHEM 110 GN(3), EMSC 100 GWS(3)[71], MATH 140 GQ(4)[1], MATH 141 GQ(4)[1], PHYS 211 GN(4) (Sem: 1-2)
MATH 251(4), PHYS 212 GN(4) (Sem: 3-4)
METEO 300(4)[1], METEO 411(4)[1], METEO 421(4)[1], METEO 431(3)[1], METEO 440(3)[1] (Sem: 5-6)
METEO 470(3)[1] (Sem: 6-8)

ADDITIONAL COURSES (19 credits)
ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)

METEO 101 GN(3)[11], or METEO 200A(1.5)[11] and METEO 200B(1.5)[11], or METEO 201(3)[11] (Sem: 1-5)
METEO 273(3) or CMPSC 101 GQ(3) or CMPSC 200 GQ(3) or CMPSC 201 GQ(3) or CMPSC 202 GQ(3) (Sem: 2-4)
MATH 230(4)[11], or MATH 231(2) [11] and MATH 232(2) [11] (Sem: 3-4)
EBF 472(3) or STAT 301 GQ(3) or STAT 401(3) (Sem: 3-6)
CAS 100 GWS(3) or ENGL 202C GWS(3) (Sem: 3-8)

REQUIREMENTS FOR THE OPTION: 27-29 credits

ATMOSPHERIC SCIENCE OPTION: (27-28 credits)

PRESCRIBED COURSES (3 credits)

METEO 422(3) (Sem: 6-8)

ADDITIONAL COURSES (21-22 credits)

Select 3-6 credits from METEO 473(3)[11] and METEO 474(3)[11] (Sem: 5-8)
Select 6-9 credits from METEO 436(3)[11], METEO 437(3)[11], and METEO 454(3)[11] (Sem: 5-8)
Select 6-13 credits from METEO 414(4), METEO 434(3), METEO 451(3), METEO 452(3), METEO 455(3), METEO 465(3), METEO 466(3), METEO 471(3), METEO 477(3), METEO 480W(3) (Up to 9 of these credits in relevant courses in Acoustics, Chemistry, Engineering, Mathematics, and Physics may be substituted with the approval of the student's adviser.) (Sem: 7-8)

SUPPORTING COURSES AND RELATED AREAS (3 credits)

Select 3 credits of W courses or their equivalent in addition to METEO 440. (Sem: 7-8)

ENVIRONMENTAL METEOROLOGY OPTION: (27-29 credits)

PRESCRIBED COURSES (9 credits)

CE 370(3), METEO 454(3)[11], METEO 455(3) (Sem: 2-8)

ADDITIONAL COURSES (18-20 credits) (May apply to General Education)

Select 15-17 credits from BIOL 110 GN(4), CE 360(3), CE 461(3), CE 475(4), CE 479(3), CHEM 112 GN(3), CHEM 113 GN(1), CHEM 450(3), CHEM 457(2), CHEM 464(3), ERM 430(3), ERM 435(3), ERM 447(3), ERM 450(3), GEOG 111 GN(3), GEOG 311(3), GEOG 313(3), GEOG 361(3), GEOG 362(3), GEOG 363(3), GEOG 417(3), GEOG 463(3), ME 405(3), ME 433(3), METEO 419(3); METEO 437(3) (Sem: 2-8)
Select 3 credits from METEO 473(3)[11] or METEO 474(3)[11] (Sem: 5-8)

GENERAL OPTION: (27 credits)

ADDITIONAL COURSES (6 credits)

Select 3 credits from METEO 436(3)[11] or METEO 437(3)[11] or METEO 454(3)[11] (Sem: 5-8)
Select 3 credits from METEO 473(3)[11] or METEO 474(3)[11] (Sem: 5-8)

SUPPORTING COURSES AND RELATED AREAS (21 credits)

Select 21 credits in consultation with advisor from 400-level METEO courses and/or 300-, or 400-level courses from the Colleges of Agricultural Sciences, Earth and Mineral Sciences, Engineering, and/or Science. With the approval of a meteorology adviser, some 200-level courses from those Colleges may also be used.(Sem: 7-8)

WEATHER FORECASTING AND COMMUNICATIONS OPTION: (28 credits)

PRESCRIBED COURSES (13 credits)

METEO 481(3), METEO 482(3) (Sem: 5-6)
METEO 414(4), METEO 415(3) (Sem: 6-8)

ADDITIONAL COURSES (15 credits)

Select 3 credits from METEO 436(3)[11] or METEO 437(3)[11] (Sem: 5-8)
Select 3-6 credits from METEO 473(3)[11] and METEO 474(3)[11] (Sem: 5-8)
Select 6-9 credits from CAS 211(3), EE 477(3) or METEO 477(3); ENGL 416(3), GEOG 333(3), GEOG 361(3), GEOG 362(3), GEOG 363(3), GEOG 417(3), GEOG 467(3), GEOSC 402 IL(3), METEO 413(3), METEO 416(3), METEO 418(3), METEO 419(3), METEO 422(3), METEO 434(3), METEO 451(3), METEO 452(3), METEO 454(3), METEO 471(3), METEO 483(3), METEO 486(1-2, max 3), any two from METEO 495A(3), METEO 495B(3), METEO 495C(3), METEO 495D(3) or METEO 495E(3) (Sem: 5-8)

WEATHER RISK MANAGEMENT OPTION: (27 credits)

PRESCRIBED COURSES (9 credits)

ECON 102 GS(3) (Sem: 1-2)
EBF 473(3) (Sem: 3-6)
METEO 460(3) (Sem: 7-8)

ADDITIONAL COURSES (18 credits)

Select 6 credits from METEO 415(3), METEO 473(3)[11] or METEO 474(3)[11] (Sem: 5-8)
Select 3 credits from METEO 436(3)[11], METEO 437(3)[11] or METEO 454(3)[11]** (Sem: 5-8)
Select 6 credits from EBF 301(3); EBF 483(3), EBF 484(3); EGEE 437(3); EGEE 438(3); or EME 460(3) (Sem: 6-8)
Select 3 credits from ECON 490(3), STAT 318(3), STAT 319(3), STAT 414(3), STAT 415(3), STAT 460(3) or STAT 462(3) (Sem: 6-8)

**Preferred choice

Integrated B.S./M.S. Program in Meteorology

The Department of Meteorology offers an integrated B.S./M.S. (IUG) Program that is designed to allow academically superior students to obtain both the B.S. and the M.S. degree in Meteorology in five years of study. In order to complete the program in five years, students interested in the Integrated B.S./M.S. Program in Meteorology must apply for admission to the Graduate School and the Integrated B.S./M.S. Program by the end of their junior year.

During the first three years, the student will follow the course scheduling of one of the options in the B.S. degree, normally the Atmospheric Sciences or the General option (see the Undergraduate *Bulletin*). Students who intend to enter the Integrated B.S./M.S. program are encouraged to take upper level classes during their first three years whenever appropriate. By the end of the junior year, students normally apply for admission to both the IUG program and to the Graduate School. Acceptance decisions will be made prior to the beginning of the senior year and M.S. advising committees appointed for successful applicants. During the senior year, IUG students follow the scheduling of the selected B.S. Meteorology option, with an emphasis on completing 500-level course work as appropriate. During the senior year, IUG students will start work on their theses or papers that are designed to meet the requirements of the M.S. degree in Meteorology. During the fifth year, IUG students take courses fulfilling the departmental M.S. degree requirements and complete their M.S. theses or papers. Typical scheduling plans for students pursuing the General or Atmospheric Sciences options are given on the departmental Web site <http://www.met.psu.edu>. Undergraduate tuition rates will apply as long as the student is an undergraduate, unless the student receives financial support, for example, via an assistantship requiring the payment of graduate tuition.

Admission Requirements

Students who wish to complete the Integrated B.S./M.S. Program in Meteorology should apply for admission to both the Graduate School and the Integrated B.S./M.S. Program by no later than the end of their junior year. In this case, successful students will be admitted formally into the graduate program in Meteorology just prior to their senior year, if their progress has been satisfactory. Admission prior to the senior year is also possible in some unusual circumstances. In all cases, admission to the program will be at the discretion of the Graduate Admissions Officer for the Department of Meteorology, who will determine the necessary criteria for all applicants. These criteria include the setting of the minimum required scores on the GRE and the minimum cumulative GPA for consideration, the receipt of sufficiently strong recommendation letters from three faculty and a strong letter of support from the department head, and the writing of an excellent proposal for a workable research project with a specific adviser; normally, evidence of significant research progress must be provided in the application as well.

The details of the program requirements can be found in the Graduate Degree Programs *Bulletin*.

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[71] The following substitutions are allowed for students attending campuses where the indicated courses is not offered: CAS 100 GWS or ENGL 202C GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Spring 2017

Blue Sheet Item #: 45-05-005

Review Date: 2/21/2017

UCA Revision #1: 8/9/06

UCA Revision #2: 7/30/07

Comments

Mining Engineering

University Park, College of Earth and Mineral Sciences (MNG E)

PROFESSOR JEFFERY L. KOHLER, *Undergraduate Program Chair*

Mining contributes to nearly 15 % of the U.S. and 25% of the global economy. Mined products are significant and critical inputs to food production, manufacturing, construction, and electricity supply, and each year every person in the U.S. requires an average of 38,500 pounds of new minerals to equip and power their day-to-day activities. Over 14,000 mines distributed throughout the U.S. supply the majority of these mined products.

The Penn State Mining Engineering Program prepares students for a career in the industrial minerals, metals, and energy industries that sustain the domestic and global economies. Importantly, the Program provides an emphasis on sustainable mining through integration of environmental, safety and health, and societal responsibility principles in the design and operation of mineral enterprises.

Graduates of the program will be prepared to work domestically or internationally to develop and operate mines; or to work in supporting activities including engineering consulting, banking, equipment development and supply, regulatory enforcement, and research. This is accomplished primarily through the curriculum, but is enhanced by an internship program, which allows qualified students to obtain practical experience through structured employment opportunities in the private and public sectors.

The curriculum is built on the foundation of mathematics, science, and general education common to engineering majors at Penn State. The courses specific to this major are designed and sequenced to provide an appropriate blend of theory, application, and design. The required courses help to provide the enabling skills for graduates to work in any facet of the vast minerals industry, and technical electives allow for in-depth study of more specialized topics. The general education opportunities are sufficiently broad and diverse in nature and scope to enable the student to tailor the educational experience to particular interests, backgrounds, and expected roles in society.

The integration of knowledge and skills acquired during the course of study in the Mining Engineering program provides graduates with the following student outcomes:

1. An ability to apply knowledge of mathematics, science, and engineering
2. An ability to design and conduct experiments, as well as to analyze and interpret data
3. An ability to design a system, component, or process to meet desired needs
4. An ability to function on multi-disciplinary teams
5. An ability to identify, formulate, and solve engineering problems

6. An understanding of professional and ethical responsibility
7. An ability to communicate effectively
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context
9. A recognition of the need for and an ability to engage in life-long learning
10. A knowledge of contemporary issues
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

PROGRAM EDUCATIONAL OBJECTIVES

1. Within three-to-five years after graduation, students are expected to be advancing in their career in the minerals industry and adapting to new situations and emerging problems, through the application of general engineering-science skills and the core technical problem-solving and design practices of the mining engineering profession, with an understanding of the need for lifelong learning.
2. Within three-to-five years after graduation, students are expected to be communicating effectively.
3. Within three-to-five years after graduation, students are expected to be functioning effectively as individuals or as members of teams.
4. Within the first year after graduation, students are expected to demonstrate an understanding of the importance of mining to society, and for working in a contemporary society in which safety and health, responsibility to the environment, and ethical behavior are required, without exception.
5. Within the first five years after graduation, students are expected to be preparing to attain licensure as a Professional Engineer.

STUDENT-TRAINEE PROGRAM: An internship program and a five-year work-study plan are available to incoming students in Mining Engineering. Numerous mining and manufacturing companies, as well as government agencies, cooperate with the University to offer structured employment opportunities during the student's academic career. In addition to earning significant funds to help finance their education, these opportunities provide valuable practical and professional experience prior to graduation. The internships normally take place in the summer, and the B.S. degree can be earned in four years. The work-study plan consists of alternating six-month periods of employment and schooling, and requires five years to earn the B.S. degree. Additional information can be obtained from the department.

Integrated B.S. in Mining Engineering (MNG E) and M.S. in Energy and Mineral Engineering (EME)

The integrated undergraduate-graduate (IUG) program between the Mining Engineering undergraduate program and the Energy and Mineral Engineering graduate program enables academically superior and research-focused MNG E undergraduate students to also obtain an M.S. degree in Energy and Mineral Engineering in five years of study. Students should refer to the Energy and Mineral Engineering graduate program in the Graduate Program Bulletin for the IUG admission and degree requirements.

(http://bulletins.psu.edu/bulletins/whitebook/graduate_degree_programs.cfm?letter=E&program=grad_eme.htm)

For the B.S. in Mining Engineering, a minimum of 131 credits is required. This baccalaureate program in Mining Engineering is accredited by the Engineering Accreditation Commission of ABET, Inc., www.abet.org.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits

(27 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)

(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:

(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:

(Included in GENERAL EDUCATION course selection)

WRITING ACROSS THE CURRICULUM:

(Included in REQUIREMENTS FOR THE MAJOR)

REQUIREMENTS FOR THE MAJOR: 113 credits

(This includes 27 credits of General Education courses: 9 credits of GN courses; 6 credits of GQ courses; 3 credits of GS courses; 6 credits of GWS courses; 3 credits of GH courses.)

PRESCRIBED COURSES (84 credits)

CHEM 110 GN(3), CHEM 111 GN(1), EMSC 100 GWS(3)[881] (Sem: 1-2)

ECON 102 GS(3), EDSGN 100(3) (Sem: 1-4)

MATH 140 GQ(4), MATH 141 GQ(4), MATH 250(3), STAT 301 GQ(3) (Sem: 1-6)

EMCH 210(5), GEOSC 1(3)[11], PHYS 211 GN(4), PHYS 212 GN(4), PHYS 213 GN(2) (Sem: 3-4)

EE 211(3), MNG 230(3)[11], MNG 331(3), MNG 422(3), (Sem: 3-8)

EME 460(3), MNPR 301(3)[11], MNPR 413(1)[11], MNG 404(2), (Sem: 5-6)

GEOSC 201(4), MNG 223(2), MNG 410(3), MNG 411(2), MNG 441(3)[11], MNG 451(4)[11] (Sem: 5-8)

ADDITIONAL COURSES (23 credits)

Select 23 credits, one course from each category a, b, c, d, e, f, g, or h:

- a. ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)
- b. PHIL 103 GH(3) or PHIL 106 GH(3) or PHIL 107 GH(3)
or PHIL 233 GH(3)/STS 233 GH(3) (Sem: 1-4)
- c. CMPSC 201 GQ(3) or CMPSC 202 GQ(3)
- d. MATH 220 GQ(2) or MATH 231(2) (Sem: 3-4)
- e. EMCH 212(3) or EMCH 212H(3) (Sem: 3-4)
- f. EME 301(3) or ME 300(3) (Sem: 4-6)
- g. EME 303(3) or CE 360(3) (Sem: 5-6)
- h. MNG 470(3) or GEOSC 470(3) (Sem: 7-8)

SUPPORTING COURSES AND RELATED AREAS (6 credits)

Select 6 credits in consultation with adviser (Students may apply 6 credits of ROTC.) (Sem: 5-8)

Course Substitutions for the Integrated B.S. in Mining Engineering (MNG E) and M.S. in Energy and Mineral Engineering (EME)

As many as twelve of the credits required for the master's degree may be applied to both the B.S. and M.S. degrees. A minimum of six credits counted for both the B.S. and M.S. degrees must be at the 500-level. Thesis and culminating/capstone experience credits may not be double counted. The undergraduate degree program officer will determine the specific undergraduate required courses for which the 500-level courses may be used to substitute to meet institutional and accreditation requirements.

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[88] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Spring Semester 2012

Blue Sheet Item #: 40-06-100

Review Date: 04/10/2012

UCA Revision #1: 8/9/06

UCA Revision #2: 7/30/07

EM

Petroleum and Natural Gas Engineering

University Park, College of Earth and Mineral Sciences (PNG E)

PROFESSOR Russell Johns, *Undergraduate Program Chair*

The B.S. program in Petroleum and Natural Gas Engineering is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone: 410-347-7700.

The undergraduate curriculum in petroleum and natural gas engineering has been designed to equip the student with the fundamentals necessary to achieve lifelong professional growth. Graduates are prepared to enter both the private and public sectors as petroleum and natural gas engineers or to pursue further education at the graduate level.

The courses are structured to serve as a melting pot for theory, application to case studies and engineering project design. This enables the student to appreciate and understand that a successful engineering design project requires a sound theoretical foundation, experimentation and engineering judgment. The thrust of the program structure emphasizes the fundamentals of mathematics and earth and engineering sciences and integrates them in application to traditional petroleum and natural gas engineering topics. Design projects are required throughout the curriculum. Execution of these projects requires an amalgamation of problem formulation strategies, testing of alternative design methodologies, feasibility studies, and economic and environmental considerations. Graduates of the program are expected to perform in various facets of the petroleum industry including drilling, production, evaluation, transportation and storage. The petroleum and natural gas engineering faculty and staff are committed to an interactive teaching and learning environment to ensure that the student is an active participant in the learning process. General education opportunities are sufficiently broad and diverse in scope to enable the student to tailor the educational experience to particular interests, background and expected role in society.

Petroleum and Natural Gas Engineering Student Outcomes:

1. Our students, at the time of their graduation, will have a working knowledge of basic math, science skills and engineering skills.
2. Our students, at the time of their graduation, will be equipped with ability to design and conduct experiments as well as to analyze and interpret data.
3. Our students, at the time of their graduation, will be ready to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
4. Our students, at the time of their graduation, will be able to function in multi-disciplinary teams.
5. Our students, at the time of their graduation, will be equipped with the necessary skills to identify, formulate and solve engineering problems.
6. Our students, at the time of their graduation, will have a thorough understanding of professional and ethical responsibilities.
7. Our students, at the time of their graduation, will be equipped with the necessary communication skills to communicate effectively.
8. Our students, at the time of their graduation, will have a broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
9. Our students, at the time of their graduation, will be instilled with the recognition of the need for, and an ability to engage in life-long learning.
10. Our students, at the time of their graduation, will attain knowledge on contemporary issues.
11. Our students, at the time of their graduation, will have an ability to use the techniques, skills and modern engineering tools that are necessary for engineering practice.

Petroleum and Natural Gas Engineering Program Educational Objectives:

1. Our graduates will integrate key science and engineering principles to address the technological challenges of the petroleum and natural gas industry.

2. Our graduates will practice in a broad range of petroleum engineering fields working on teams that create innovative solutions to the most pressing problems of the petroleum and natural gas industry by implementing the ideals of ethical behavior, professionalism, and environmental sensitivity and social awareness.
3. Our graduates will be recognized as critical and independent thinkers and will assume positions of leadership in defining the social, intellectual, business and technical dimensions of the professional organizations they belong to.
4. Our graduates will continue their life-long learning process and participate in graduate education to remain as effective professionals in the workplace of the future.

ENTRANCE TO MAJOR-- (Effective for students admitted beginning Summer 2013) -- In the event that the major is under enrollment control, a higher minimum cumulative grade-point average (GPA) than the minimum described by University Policies is likely to be needed. In addition to this minimum grade point average requirement, the following entrance to major requirements must also be completed with a minimum grade of C: CHEM 110 (GN)(3) [1], CHEM 112 (GN)(3)[1], MATH 140 (GQ)(4)[1], MATH 141 (GQ)(4)[1], and PHYS 211 (GN)(4)[1]. These courses must be completed by the end of the semester during which the entrance to major process is carried out. To be eligible for consideration for entrance to this major, students must be enrolled in the College of Earth and Mineral Sciences or Division of Undergraduate Studies at the time that they confirm their major choice.

Integrated B.S. in Petroleum and Natural Gas Engineering (PNG E) and M.S. in Energy and Mineral Engineering (EME)

The integrated undergraduate-graduate (IUG) program between the Petroleum and Natural Gas Engineering undergraduate program and the Energy and Mineral Engineering graduate program enables academically superior and research-focused PNG E undergraduate students to also obtain an M.S. degree in Energy and Mineral Engineering in five years of study. Students should refer to the Energy and Mineral Engineering graduate program in the Graduate Program Bulletin for the IUG admission and degree requirements.
(http://bulletins.psu.edu/bulletins/whitebook/graduate_degree_programs.cfm?letter=E&program=grad_eme.htm)

For the B.S. degree in Petroleum and Natural Gas Engineering, a minimum of 129 credits is required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

GENERAL EDUCATION: 45 credits
(30 of these 45 credits are included in the REQUIREMENTS FOR THE MAJOR)
(See description of General Education in this bulletin.)

FIRST-YEAR SEMINAR:
(Included in REQUIREMENTS FOR THE MAJOR)

UNITED STATES CULTURES AND INTERNATIONAL CULTURES:
(Included in GENERAL EDUCATION course selection)

WRITING ACROSS THE CURRICULUM:
(Included in REQUIREMENTS FOR THE MAJOR)

REQUIREMENTS FOR THE MAJOR: 114 credits
(This includes 30 credits of General Education courses; 3 credits of GH courses; 9 credits of GN courses; 6 credits of GQ courses; 3 credits of GS courses; 9 credits of GWS courses.)

PRESCRIBED COURSES (99 credits)
CHEM 110 GN(3)[1], CHEM 111 GN(1), CHEM 112 GN(3)[1], ECON 102 GS(3), EMSC 100 GWS(3)[88] (Sem: 1-2)
MATH 140 GQ(4)[1], MATH 141 GQ(4)[1], MATH 230(4), MATH 251(4), PHYS 211 GN(4)[1], PHYS 212 GN(4)[1], PHYS 213 GN(2) (Sem: 1-4)
EMCH 210(5)[77], EMCH 212(3), GEOSC 1(3) (Sem: 3-4)
EME 301(3)[1], EME 303(3)[1], EME 460(3), GEOSC 454(3), PNG 405(3)[1], PNG 406(1)[1], PNG 410(3)[1], PNG 450(3)[1], PNG 451(1)[1], PNG 475(3)[1], PNG 490(1) (Sem: 5-6)
ENGL 202C GWS(3), PNG 420(4), PNG 425(3), PNG 430(3), PNG 440(3), PNG 480(3), PNG 482(1), PNG 491(1), PNG 492(1) (Sem: 7-8)

ADDITIONAL COURSES (9 credits)
Select 9 credits: one course from categories a, b, and c.
a. ENGL 15 GWS(3) or ENGL 30 GWS(3) (Sem: 1-2)
b. PHIL 103 GH(3), PHIL 106 GH(3), PHIL 107 GH(3), or PHIL 233 GH(3) (Sem: 3-4)
c. CMPSC 201 GQ(3) or CMPSC 202 GQ(3) (Sem: 5-6)

SUPPORTING COURSES AND RELATED AREAS (6 credits)
Select 6 credits in consultation with adviser (Students may apply 6 credits of ROTC.) (Sem: 7-8)

Course Substitutions for the Integrated B.S. in Petroleum and Natural Gas Engineering (PNG E) and M.S. in Energy and Mineral Engineering (EME)

As many as twelve of the credits required for the master's degree may be applied to both the B.S. and M.S. degrees. A minimum of six credits counted for both the B.S. and M.S. degrees must be at the 500-level. Thesis and culminating/capstone experience credits may not be double counted. The undergraduate degree program officer will determine the specific undergraduate required courses for which the 500-level courses may be used to substitute to meet institutional and accreditation requirements.

[1] A student enrolled in this major must receive a grade of C or better, as specified in Senate Policy 82-44.

[77] Students at commonwealth campuses and/or transfer students can substitute the combination of EMCH 211 and EMCH 213.

[88] The following substitutions are allowed for students attending campuses where the indicated course is not offered: CAS 100 GWS can be substituted for EMSC 100 GWS.

Last Revised by the Department: Spring Semester 2013

Blue Sheet Item #: 42-01-029

Review Date: 08/20/13

UCA Revision #1: 8/9/06
UCA Revision #2: 7/30/07

EM

Associate Degrees

Minors

Climatology Minor

University Park, College of Earth and Mineral Sciences (CLIMA)

Climate is a central component of the physical environment, playing an important role in a wide range of human activities. The ability to force changes in the global climate system may be one of the more significant ways in which human society will impact Earth's physical environment in the near future. The climatology minor in the College of Earth and Mineral Sciences is an interdisciplinary program drawing from the fields of meteorology, geography, and geosciences. The minor provides an overview of the physical processes that control present-day climate. It also provides an introduction to the history of climate change through geologic time, and presents some of the causes and consequences of potential future climate change and variability.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 18 credits

ADDITIONAL COURSES (18 credits)

Select 18 credits from:

EARTH 103 GN(3) (Sem: 1-8)

GEOG 438(3), GEOG 412(3), GEOG 310(3), GEOG 417(3), GEOSC 320(3), METEO 300(3) (Sem: 5-8)

Last Revised by the Department: Summer Session 2000

Blue Sheet Item #: 28-05-015

Review Date: 8/5/03

EM

Earth and Sustainability

College of Earth and Mineral Sciences

By the time current undergraduates send their children to college, Earth's population will have increased to more than eight billion people. One or more metropolitan areas in our increasingly crowded world will have experienced a devastating earthquake or volcanic eruption, sea level rise will be inundating low-lying coastal cities such as Jakarta along with whole island nations, energy resources will be less available and more expensive, and our climate will be warmer and characterized by more frequent extreme weather events. How we choose to plan for and attempt to mitigate these "grand challenges" will have consequences for individuals, nations, and our global socioeconomic and political systems.

Personal and collective actions are needed to ensure the sustainable use of our natural resources and environmental systems-land, air, and water-in an ethical and responsible manner. The United States needs to build robust educational pathways for its citizenry to develop the global perspective, cultural sensitivity, economic wisdom, and scientific acumen to inform their actions and address these grand challenges. The geosciences (marine, Earth, and atmospheric sciences) that explain the workings of the Earth system provide critical insight into all of these challenges and, consequently, must be firmly integrated into those educational pathways. These programs seek to promote that integration through engaging the geoscience community and their colleagues in allied disciplines in the development of high-quality educational materials, and mechanisms by which these materials can be effectively brought to large numbers of students.

The goal of this minor is to dramatically increase geoscience literacy of undergraduate students, including the large majority that do not major in the geosciences, and especially adult learners through the on-line program, such that they are better positioned to make sustainable decisions in their lives and as part of the broader society.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 18 credits

PRESCRIBED COURSES: (6 credits)

EARTH 103(3)

EARTH 402(3)

ADDITIONAL COURSES (9 credits)

Select 9 credits from: EARTH 104 (3), EARTH 111(3), EARTH 107(3), GEOG 3/AG 3(3)

SUPPORTING COURSES AND RELATED AREAS (3 credits)

Select 3 credits from the approved list of EMS courses. Approved courses are:

EGEE 401(3), EME 444(3), EME 460(3), GEOG 412(3), GEOG 430(3), GEOG 431(3), GEOG 432(3), GEOG 438(3), GEOG 469(3), GEOSC 402(3), GEOSC 451(3), GEOSC 452(3), METEO 469(3)

Last Revised by the Department: Fall Semester 2016

Blue Sheet Item #: 45-03-017

Review Date: 11/15/2016

Earth Systems Minor

University Park, College of Earth and Mineral Sciences (EASYS)

The recognition that environmental problems are global in extent, and impact on many different components of the Earth System simultaneously, requires that we adopt a large-scale and interdisciplinary approach to questions of global change and the interactions of the physical and human environments. The Earth Systems minor follows such an approach and offers undergraduates the opportunity to study the Earth as an integrated system. The Earth Systems minor is a science minor offered through the College of Earth and Mineral Sciences. It provides a wider interdisciplinary perspective for majors in the traditional Earth Science disciplines (geography, geoscience, and meteorology), and provides an introduction to Earth Sciences and a broad exposure to Earth Systems/Environmental Studies for other science and engineering majors. Students may apply up to 6 credits from courses in the major department to satisfy the minor requirements.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENT FOR THE MINOR: 18 credits

PRESCRIBED COURSES (3 credits)

EARTH 2 GN(3) (Sem: 3-6)

ADDITIONAL COURSES (6 credits)

Select 6 credits from EARTH 103 GN(3), EMSC 470(1-6), GEOG 430(3), GEOSC 310(4), or METEO 300(3) (Sem: 5-8)

SUPPORTING COURSES AND RELATED AREAS (9 credits)

Select 9 credits from the Earth Systems Committee's approved list of courses (Sem: 5-8)

Last Revised by the Department: Spring Semester 2000

Blue Sheet Item #: 28-05-018

Review Date: 2/15/00

EM

Electrochemical Engineering Minor

University Park, College of Earth and Mineral Sciences (ELCHE)

The electrochemical engineering minor is designed to equip students with the knowledge necessary to achieve the following educational objectives: become valuable contributors in addressing society's clean energy needs and demands especially in the electrochemical power generation sector; and educators, practicing engineers, and national leaders in electrochemical energy conversion and storage. The minor integrates skill sets in fundamentals of electrochemistry (e.g. chemistry, physics, mathematics, thermodynamics, and chemical kinetics) and electrochemical engineering applications (batteries, solar, flow and fuel cells, electrochemical synthesis and corrosion) to ensure successful career opportunities and growth within electrochemical power generation industries, government agencies, and academia. The curriculum should allow students in energy related programs such as chemical, civil, electrical, environmental, mechanical, and materials science and engineering to readily take advantage of the minor and be better prepared for careers in clean power generation and future green technologies.

The integration of knowledge and skills acquired through the inquiry-based teaching methods should enable students of the program to achieve the following student educational outcomes:

- solve problems relating to the production, storage, distribution and utilization of electrochemical energy and the associated environmental issues
- design and conduct experiments, acquire data, define, analyze, and interpret data, and solve practical, complex problems on a variety of electrochemical technologies such as batteries, solar cells, flow and fuel cells, electrolyzers, and supercapacitors
- integrate professional, ethical, social and environmental factors in electrochemical engineering design and problem solving and understand the impact of these factors on global energy issues
- develop the ability to communicate effectively in writing and orally and build teamwork
- acquire the desire for lifelong learning to maintain technical competence and keep abreast of new developments in the field.

A grade of C or better is required for all courses in the minor.

For the minor in Electrochemical Engineering, a minimum of 35 credits is required.

REQUIREMENTS FOR THE MINOR: 35 credits

PRESCRIBED COURSES (20 credits)

CHEM 112 GN(3), ESC 455 (3), EGEE 441(3), MATH 251(4), MATSE 421 (3), PHYS 212 GN(4) (Sem: 7-8)

ADDITIONAL COURSES (15 Credits)

Select 6 credits from: EME 301(3), EME 303(3) or CHE 220(3), CHE 330(3) or ME 300(3), ME 320(3) or MATSE 401(3), MATSE 402(3)

Select 9 credits from EGEE 420(3), EGEE 437(3), EGEE 436(3), EME 407(3), ME 403(3) (Sem: 7-8)

Last Revised by the Department: Fall Semester 2015

Blue Sheet Item #: 44-02-017

Review Date: 09/27/2011

Electronic and Photonic Materials Minor

University Park, College of Earth and Mineral Sciences (E P M)

Electronic and photonic materials have greatly changed modern life. Without them, computers, telecommunication systems, compact disc players, video cameras, and all the electronics with which we have become accustomed would not be possible. The study of electronic and photonic materials is a natural bridge between the fields of electrical engineering and material science. Students in electrical engineering will benefit from this minor because they will better understand the materials with which they will design electronic and photonic devices, such as transistors on a computer chip or semiconductor lasers in a compact disc player. Training in the field of electronic and photonic materials requires study of the processing and characterization of these materials to help engineers develop ways to lower cost and improve performance. This knowledge will help prepare students to enter the semiconductor industry or pursue graduate studies.

A grade of C or better is required for all courses in the minor.

For a MINOR in Electronic and Photonic Materials a minimum of 35 credits are required.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 35 credits

PRESCRIBED COURSES (23 credits)

EE 310(4), MATH 140(4), MATH 141(4), MATH 231(2), MATSE 201(3) (Sem: 1-4)

CHEM 112 GN(3), EE 441(3) (Sem: 5-8)

ADDITIONAL COURSES (12 credits)

Select 3 credits from ESC 314(3) or an approved EE course (Sem: 1-4)

Select 3 credits from MATSE 450(3) or MATSE 455(3) (Sem: 5-8)

Select 6 credits from EE 442(3), ESC 445(3), MATSE 400(3), MATSE 401(3), MATSE 402(3), MATSE 413(3), MATSE 417(3), MATSE 430(3), MATSE 435(3), MATSE 450(3), MATSE 455(3) (Sem: 5-8)

Last Revised by the Department: Fall 2015

Blue Sheet Item #: 44-03-029

Review Date: 11/17/15

UCA Revision #2: 7/27/07

EM

Energy Business and Finance Minor

*University Park: College of Earth and Mineral Sciences (EBF) Contact: Professor Seth Blumsack, Program Officer
World Campus*

The minor in Energy, Business and Finance is an offering of the College of Earth and Mineral Sciences. The minor introduces students to financial, investment, and management concepts applied to private sector organizations whose operation emphasizes the Earth and its environment, the energy and mineral industries, or the development of new and enhanced materials. The minor focuses on the leadership and information strategies characteristic of enterprises that are succeeding in a rapidly integrating global economy.

The minor provides science and engineering students an introduction to basic entrepreneurial and business concepts to help prepare them for success in a changing professional environment. It also provides other Penn State students an opportunity to focus on business strategies in the Earth resources, environmental, and materials industries. A minimum of 27 credits is required for the minor. A student enrolled in this minor must receive a grade C or better in all courses in the minor. Advising is available through the EMS Student Center (25 Deike Building) or the professor in charge.

Scheduling Recommendations by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 27-29 credits

PRESCRIBED COURSES (12 credits)

ECON 102 GS(3), EBF 200 GS(3), EBF 301(3), EME 460(3) (Sem: 5-8)

ADDITIONAL COURSES (9-11 credits)

Select 3-4 credits from: MATH 22 GQ(3); MATH 110 GQ(4); MATH 140 GQ(4) (Sem: 3-4)

Select 3-4 credits from: STAT 200 GQ(4); STAT 401(3); EBF 472(3) (Sem: 5-6)

Select 3 credits from: EGEE 101 GN(3) or EGEE 102 GN(3) or EGEE 120 GS;US;IL(3) (Sem: 5-6)

SUPPORTING COURSES AND RELATED AREAS (6 credits)

Select 6 credits from the approved list of EMS courses. Approved courses are: EBF 401 (3), EBF 402(3), EBF 473(3), EBF 483(3), EBF 484(3), EGEE 401(3), EME 444(3), GEOG 424 US;IL(3), GEOG 430(3), GEOG 431(3), GEOG/EME 432(3), GEOG 444(3), GEOG 469(3), GEOSC 402 IL(3), GEOSC 454(3), and METEO 473(3) (Sem: 7-8).

Last Revised by the Department: Fall Semester 2017

Blue Sheet Item #: 46-02-015

Review Date: 10/3/2017

EM/BA

Energy Engineering Minor

University Park, College of Earth and Mineral Sciences (ENENG)

Professor Sarma Pisupati, Program Officer

The minor in Energy Engineering is designed to provide students in engineering, science, and energy business and finance (EBF) with additional courses, exposure, and experiences to the principles and applications of energy engineering. Courses available to students include thermal sciences; petroleum and natural gas processing; renewable/sustainable energy; chemistry of fuels; electrochemical, chemical and nuclear energy conversion processes; physical processes in energy engineering; air pollution; and green engineering and environmental compliance. As a result, the selection of this minor can provide additional career options for students in a wide range of offerings at Penn State.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 18 credits

ADDITIONAL COURSES (18 credits)

Select 9 credits from the following courses: EGEE 302(3), EGEE 304(3), EGEE 411(3), EGEE 420(3), EGEE 430(3), EME 301(3) (Sem: 5-6)

Select 9 credits from the following courses: EGEE 433(3), EGEE 437(3), EGEE 438(3), EGEE 441(3), EGEE 451(3), EGEE 464(3), EGEE 470(3), FSC 431(3), FSC 432(3) (Sem: 7-8)

Last Revised by the Department: Fall Semester 2007

Blue Sheet Item #: 35-05-074

Review Date: 3/4/09

EM

Environmental Systems Engineering Minor

University Park, College of Earth and Mineral Sciences (ENVSE)

PROFESSOR WILLIAM GROVES

The minor in environmental systems engineering is for students interested in environmental issues associated with the extraction, processing and utilization of mineral and energy resources and their solutions. It provides an opportunity for students to understand and appreciate the interrelationship between energy and the environment, be exposed to the basic courses in environmental systems engineering, and to appreciate and evaluate the impact of environmental pollution control on viability of the profitability and feasibility of operations associated with the safe extraction, processing and utilization of mineral and energy resources. A minimum of 18 credits is required for the minor. A student enrolled in this minor must receive a grade C or better in all courses in the minor. Advising is available through the professor in charge.

Scheduling Recommendations by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 18 credits

PRESCRIBED COURSES (15 credits)

EME 460(3), ENVSE 406(3), ENVSE 427(3), ENVSE 450(3), MNPR 301(3) (Sem: 5-7)

ADDITIONAL COURSES (3 credits)

EGEE 470(3), ENVSE 400(3), or MNPR 426(3) (Sem: 5-8)

Last Revised by the Department: Fall Semester 2010

Blue Sheet Item #: 39-02-012

Review Date: 09/28/2010

Geographic Information Science Minor

University Park, College of Earth and Mineral Sciences (G I S)

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 18 credits

PRESCRIBED COURSES (3 credits)

GEOG 160 GS(3) (Sem: 3-6)

ADDITIONAL COURSES (15 credits)

Select 6 credits from GEOG 361(3), GEOG 362(3), or GEOG 363(3) (Sem: 3-6)

Select 9 credits (at least 6 credits at the 400-level) from GEOG 323(3), GEOG 485(3), GEOG 461(3), GEOG 467(3), GEOG 417(3), GEOG 459(3), GEOG 463(3), or GEOG 468(3) (Sem: 5-8)

Last Revised by the Department: Fall Semester 2006

Blue Sheet Item #: 34-06-195

Review Date: 4/11/06

EM

Geography Minor

University Park, College of Earth and Mineral Sciences (GEOG)

The Geography minor can complement most majors in the social sciences, physical sciences, biological sciences, and technical disciplines. The geography minor is flexible so that students can tailor their course choices to accommodate individual interests. A broadly based approach to selecting minor courses can be appropriate for students whose majors are highly specialized or narrowly focused. Alternatively, students may choose to fulfill geography minor requirements with a particular content emphasis, such as an interest in environmental issues or urban and regional planning. Looking through course choices and talking with geography staff can make earning the geography minor an important enhancement to one's academic program.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 18 credits

SUPPORTING COURSES AND RELATED AREAS (18 credits)

In consultation with a geography adviser:

Select 3 credits in physical geography (Sem: 3-6)

Select 3 credits in human geography (Sem: 3-6)

Select 6 credits of additional geography courses (Sem: 3-6)

Select 6 credits of 400-level geography courses (Sem: 5-8)

Last Revised by the Department: Summer Session 2000

Blue Sheet Item #: 28-04-090

Review Date: 11/01

EM

Geophysics Minor

University Park, College of Earth and Mineral Sciences (GPHYS)

The Geophysics minor provides the opportunity for students from outside the Geosciences to apply the physics, quantitative, and technical skills they are developing in their major program to the geophysical aspects of Earth Science,

including seismology, volcanology, natural hazards, environmental geophysics, and petroleum and mineral exploration. For students majoring in Geosciences, the completion of the minor will strengthen their physics/quantitative background and develop links between theory and application for these technical and quantitative skills. The minor will prepare students for graduate programs in geophysics, and/or employment opportunities in the environmental and exploration industries. The minor consists of 18-20 credits satisfying the requirements below.

A grade of C or better is required for each course in the minor.

Recommended Scheduling by Semester Standing (e.g., Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 29-32 credits

PRESCRIBED COURSES (11 credits)

GEOSC 1(3), MATH 140 GQ(4), PHYS 212 GN(4) (Sem: 3-7)

ADDITIONAL COURSES (18-21 credits)

Select 4 credits from:

Non-Geoscience Majors (i.e., Math, Physics, Engineering):

GEOSC 203(4) (Sem: 3-7)

Geoscience Majors:

PHYS 212 GN(4) (Sem: 3-6)

Non-Geoscience Majors (i.e., Math, Physics, Engineering):

Select 3 credits from: GEOSC 1(3); GEOSC 10 GN(3); GEOSC 40 GN(3); GEOSC 109H GN(3); EARTH 2 GN(3); EARTH 101 GN(3); EARTH 105 GN(3); EARTH 106 GN(3) (Sem: 1-4)

Select 11-13 credits from: GEOSC 402 IL(3); GEOSC 434(3); GEOSC 452(3); GEOSC 483(3); GEOSC 487(3); GEOSC 488(4); GEOSC 489(4) (Sem: 5-8)

Geoscience Majors: (Geoscience majors may not double count these courses in their major)

Select 3-4 credits from: MATH 220 GQ(2-3); MATH 230(4); MATH 231(2); MATH 232(2); MATH 250(3); MATH 251(4) (Sem: 3-6)

Select 11-13 credits from: GEOSC 402 IL(3); GEOSC 434 (3); GEOSC 452(3); GEOSC 483(3); GEOSC 487(3); GEOSC 488(4); GEOSC 489(4) (Sem: 5-8)

Last Revised by the Department: Fall Semester 2015

Blue Sheet Item #: 44-01-059

Review Date: 8/25/2015

Geosciences Minor

University Park, College of Earth and Mineral Sciences (GEOSC)

The Geosciences minor provides a foundation in the physical and material aspects of the solid Earth, as well as an introduction to field techniques and technical writing. Advanced course work should reflect the students' individual interests. Areas of focus include, but are not limited to: earth materials, evolution of the Earth and life, hydrogeology, environmental geology, natural hazards, plate tectonics, geophysics, climate change. The minor consists of 18 credits of course work, some of which are filled through specific courses as indicated below.

A grade of C or better is required in each course in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 18 credits

PRESCRIBED COURSES (7 credits)

GEOSC 21 GN(3) (Sem: 1-6)

GEOSC 201(4) (Sem: 3-8)

ADDITIONAL COURSES (6 credits)

Select 3 credits from GEOSC 1(3), GEOSC 20 GN(3), or GEOSC 71(3) (Sem: 1-6)

Select 3 credits from GEOSC 470(3), EMSC 470(3-6) (Sem: 5-8)

SUPPORTING COURSES AND RELATED AREAS (5 credits)

Select 5 credits from a number of courses covering a variety of disciplines and fields of interest. Consult with your adviser. At least 3 credits in this category must be taken at the 400 level; the remaining 2 credits may be at the 200 level or above. (Sem: 5-8)

Last Revised by the Department: Summer Session 2002

Blue Sheet Item #: 30-07-082

Review Date: 4/9/02

EM

Information Sciences and Technology for Earth and Mineral Sciences

Minor

University Park, College of Earth and Mineral Sciences (ISEMS)

Information Systems are a core component of any research, educational or industrial enterprise in the Earth and Materials Sciences. In addition, the science and engineering disciplines represented in the College have a particular focus on numerical modeling and simulation systems, and on the analysis and management of very large data sets. The EMS - IST minor provides students a basic introduction to information sciences and information technology through courses in the core curriculum of the School of Information Sciences and Technology. Students then select from a group of interdisciplinary EMS courses that focus on the particular interests of the College.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 19 credits

PRESCRIBED COURSES (13 credits)

IST 110 GS(3) (Sem: 1-2)

IST 210(3) (Sem: 3-4)

IST 220(3), GEOG 463(3) (Sem: 5-6)

ADDITIONAL COURSES (6 credits)

Select 6 credits from GEOG 461(3), GEOG 464(3), GEOG 485(3), MATSE 419(3), METEO 473(3), METEO 474(3), PNG 430(3) (Sem:5-8)

Last Revised by the Department: Spring Semester 2015

Blue Sheet Item #: 43-05-051

Review Date: 02/24/2015

Meteorology Minor

University Park, College of Earth and Mineral Sciences (METEO)

Students pursuing the 39-credit Meteorology minor seek to broaden their education by specializing in an applied science. As for Meteorology majors, students minoring in Meteorology must have a strong background in Mathematics and Physics. Eleven of the 20 Meteorology credits come from the three required courses of METEO 300, METEO 421, and METEO 431. The remaining nine credits come from 100-, 200-, 300-, or 400-level METEO courses, at least one of which must be at the 400 level. Completion of the three required courses ensures that students will have the foundational atmospheric science material that they need to register for the remaining nine Meteorology credits. In consultation with a Meteorology adviser, students may choose these elective courses from a variety of sub-specialties, including Air Quality Studies, Atmospheric Dynamics, Atmospheric Physics, Climatology, Computer Applications, and Weather Analysis and Forecasting.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 39 credits

PRESCRIBED COURSES (30 credits)

METEO 300(4), METEO 421(4), METEO 431(3) (Sem. 5-6)

CHEM 110 GN(3), MATH 231(2), MATH 232(2), MATH 251(4), PHYS 211 GN(4), PHYS 212 GN(4) (Sem: 5-6)

ADDITIONAL COURSES (9 credits)

Select 9 credits of 100-, 200-, 300-, or 400-level Meteorology; at least 3 credits must be at the 400 level. (Sem. 5-8)

Last Revised by the Department: Fall Semester 2015

Blue Sheet Item #: 44-01-060

Review Date: 8/25/15

EM

Mining Engineering Minor

University Park, College of Earth and Mineral Sciences (MNG E)

Professor Jeffery Kohler, Program Officer

The minor in Mining Engineering offers a specialized program for students in many other broad-based, technical majors, such as those in engineering or science. The demand for professionals with the training and skills for a career in the minerals- and energy-recovery profession far exceeds the supply. Mineral exploration and evaluation, mine development, marketing, health and safety, environmental protection, and mine management are all areas of industry employment. It is recommended that students wishing to pursue this minor come from an engineering or science major. As a result, the selection of this minor can provide additional career options for students in a wide range of offerings at Penn State.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 18 credits

PRESCRIBED COURSES (18 credits)

MNG 230(3), MNG 331(3), MNG 404(2), MNG 410(2), MNG 412(3), MNG 422(3), and MNG 441(3) (Sem: 3-8)

Review Date: Fall Semester 1997

EM

Petroleum and Natural Gas Engineering Minor

University Park, College of Earth and Mineral Sciences (PNG E)

PROFESSOR Russell Johns, *Program Officer*

The minor in petroleum and natural gas engineering is for students interested in the drilling and production of oil and gas. It provides an opportunity for students to understand and appreciate the relationship between petroleum and natural gas demand, production and their environment impact. Students are exposed to the basic courses in petroleum and natural gas extraction, particularly as they relate to drilling, production and characterization. A minimum of 18 credits is required for the minor. A student enrolled in this minor must receive a grade C or better in all courses in the minor. Advising is available through the professor in charge.

Scheduling Recommendations by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 23 credits

PRESCRIBED COURSES (14 credits)

PNG 405(3), PNG 406(1), PNG 410(3), PNG 440(3), PHYS 211 GN(4) (Sem: 5-7)

ADDITIONAL COURSES (9 credits)

Select 9 credits from the following list:

PNG 411(1), PNG 420(4), PNG 425(3), PNG 430(3), PNG 450(3), PNG 451(1), PNG 475(3), PNG 480(3), PNG 482(1), PNG 489(3), PNG 496(1) (Sem: 5-8)

Last Revised by the Department: Fall Semester 2015

Blue Sheet Item #: 44-01-061

Review Date: 8/25/2015

Review Date: 09/28/2010

Polymer Science Minor

University Park, College of Earth and Mineral Sciences (PLMSC)

Robert Kimel, Associate Head Materials Science and Engineering

The goal of the polymer science minor is to produce graduates who have a first-hand knowledge of the relationships between the synthesis, structure, properties and processing of polymer materials. Students are required to take MATSE 443 (3 credits), MATSE 441; MATSE 445; MATSE 446; MATSE 447 which provides a broad overview of the subject, then select 3 credits chosen from a suite of courses that deal with polymer synthesis, microstructure and morphology, properties and processing.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 23 credits

PRESCRIBED COURSES (8 credits)

CHEM 210(3), MATH 231(2), MATSE 443(3) (Sem: 5-8)

ADDITIONAL COURSES (15 credits)

Select 3 credits from: BMB 474(3), EMCH 446(3), MATSE 447(3), MATSE 473(1), MATSE 474(1), MATSE 494W(3), and MATSE 496(1-3) (Sem: 5-8)

Select 12 credits from: MATSE 441(3), MATSE 442(3), MATSE 444(3), MATSE 445(3), or MATSE 446(3) (Sem: 5-8)

Last Revised by the Department: Fall Semester 2015

Blue Sheet Item #: 44-01-061A

Review Date: 8/25/2015

UCA Revision #1: 9/1/06

EM

Watersheds & Water Resources Minor

University Park, College of Earth and Mineral Sciences (W W R)

Watersheds are important landscape features that control the biogeochemistry of natural waters. This interdisciplinary minor enables students to learn the fundamental processes governing the transport and chemical evolution of surface and subsurface waters. It provides a complement to elective and required coursework in earth sciences, resource management, wastewater treatment, and/or environmental planning. Students in this program will learn to apply fundamental concepts of chemistry, biology, geoscience, and landscape evolution to processes operating at the watershed scale. Learning objectives for the minor include excellence in written and oral expression, the ability to collect and interpret data from dynamic natural systems, and rigor in scientific thought.

A grade of C or better is required for all courses in the minor.

Scheduling Recommendation by Semester Standing given like (Sem: 1-2)

REQUIREMENTS FOR THE MINOR: 18 credits

ADDITIONAL COURSES (18 credits)

Select 18 credits from the WWR committee's approved list of courses, which includes but is not limited to courses listed below (at least 6 credits must be taken at the 400 level):

BE 307(3), BE 467(4), ASM 217(3), ASM 327(3), CE 370(3), CE 371(3), CE 461(3), CE 473(3), CE 475(4), CHEM 202(3), CHEM 402(3), ERM 411(3), ERM 435(3), ERM 450(3), ENVE 411(3), ENVE 415(3), ENVSE 408(3), FOR 470(3), FOR 471(1), GEOG 431(3), GEOSC 201(4), GEOSC 340(3), GEOSC 412(3), GEOSC 413(3), GEOSC 419(3), GEOSC 445(4), GEOSC 452(3), METEO 417(3), METEO 448(3), SOILS 405(3), SOILS 418(3), WFS 410(3), WFS 422(3) (Sem: 5-8)

Last Revised by the Department: Summer Session 2008

Blue Sheet Item #: 36-04-027

Review Date: 1/15/08

UCA Revision #1: 8/14/06

EM

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