Earth Sciences

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Faculty

Ilya N. Bindeman, professor (stable isotope geochemistry, volcanology). BS, 1988, Moscow; PhD, 1998, Chicago. (2004)

Edward B. Davis, assistant professor (vertebrate paleontology). BS, 1999, Tennessee, Knoxville; PhD, 2005, California, Berkeley. (2013)

Rebecca J. Dorsey, professor (sedimentology, basin analysis). BS, 1983, Vermont; MA, 1986, PhD, 1989, Princeton. (1997)

Josef Dufek, professor (volcanology). BS, 2000, Chicago; MS, 2004, PhD, 2006, Washington (Seattle). (2017)

Thomas Giachetti, assistant professor (volcanology). MS, 2006, PhD, 2010, Université Blaise Pascal, Clermont-Ferrand. (2015)

Emilie Hooft Toomey, associate professor (marine geophysics). BSc, 1990, Trinity College, Toronto; PhD, 1997, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution. (1999)

Samantha Hopkins, associate professor (paleontology). See **Robert Donald Clark Honors College**.

Eugene D. Humphreys, professor (seismology, regional tectonics). BS, 1974, MS, 1978, California, Riverside; PhD, 1985, California Institute of Technology. (1985)

Qusheng Jin, associate professor (biogeoscience). BS, 1994, Nanjing; MS, 1997, Chinese Academy of Sciences; PhD, 2003, Illinois, Urbana-Champaign. (2005)

A. Dana Johnston, professor (experimental petrology, geochemistry). BS, 1976, Bates; MS, 1978, PhD, 1983, Minnesota. (1986)

Leif A. Karlstrom, assistant professor (volcanology, geomorphology, fluid mechanics). BS, 2006, Oregon; PhD, 2011, California, Berkeley. (2011)

Diego Melgar, assistant professor (earthquake seismology, tsunamis, geodetic imaging). BEng., 2009, Universidad Nacional Autonoma de Mexico; MS, 2010, PhD, 2014, Scripps College. (2017)

Marli B. Miller, senior instructor (structural geology). BA, 1982, Colorado College; MS, 1987, PhD, 1992, Washington (Seattle). (1997)

Matthew Polizzotto, associate professor (soil and environmental hydrogeochemistry). BS, BA, 2001, Rochester; PhD, 2007, Stanford. (2016)

Mark H. Reed, professor (mineral deposits, aqueous geochemistry). BA, 1971, Carleton; MS, 1974, PhD, 1977, California, Berkeley. (1979)

Alan W. Rempel, professor (geomechanics and applied mathematics). BASc, 1991, MSc, 1995, British Columbia; PhD, 2001, Cambridge. (2004)

Gregory J. Retallack, professor (paleobotany, paleosols). BA, 1973, Macquarie; PhD, 1978, New England University, Australia. (1981)

Joshua J. Roering, professor (surface processes, geomorphology). BS, 1994, MS, 1995, Stanford; PhD, 2000, California, Berkeley. (2000)

Valerie Sahakian, assistant professor (tectonics, ground seismology, marine geophysics). BS, 2009, Rhode Island; MS, 2010, PhD, 2015, Scripps College. (2018)

David A. Sutherland, associate professor (physical oceanography). BA, 2001, North Carolina, Wilmington; PhD, 2008, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution. (2011)

Amanda M. Thomas, assistant professor (earthquake seismology and fault mechanics). BS, 2007, Georgia Institute of Technology; PhD, 2012, California, Berkeley. (2015)

Douglas R. Toomey, professor (seismology, tectonics, midocean ridges). BS, 1981, Pennsylvania State; PhD, 1987, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution. (1990)

Paul J. Wallace, professor (igneous petrology, volcanology, geochemistry). BS, 1986, George Washington University; PhD, 1991, California, Berkeley. (2001)

James M. Watkins, associate professor (experimental petrology, geochemistry, volcanology). BS, 2005, Wisconsin, Eau Claire; PhD, 2010, Cailfornia, Berkeley. (2012)

Ray J. Weldon, professor (neotectonics, structural and quaternary geology). BA, 1977, Pomona; PhD, 1986, California Institute of Technology. (1987)

Research Staff

Dennis K. Fletcher, research assistant. BS, 1996, Oregon. (2006)

Leland O'Driscoll, seismic field technician. PhD, 2012, Oregon (2015)

Sara Meyer, field technician. BS, 2010, California, Santa Cruz; IT specialist certification, 2015, Alaska, Fairbanks. (2017)

James Palandri, research associate. PhD, 2000, Oregon. (2001)

Lucy Walsh, research assistant. MS, 2012, Oregon. (2017)

Emeriti

M. Allan Kays, professor emeritus. BA, 1956, Southern Illinois; MA, 1958, PhD, 1960, Washington (St. Louis). (1961)

Alexander R. McBirney, professor emeritus. BS, 1946, United States Military Academy, West Point; PhD, 1961, California, Berkeley. (1965)

William N. Orr, professor emeritus. BS, 1961, Oklahoma; MA, 1963, California, Riverside and Los Angeles; PhD, 1967, Michigan State. (1967)

Jack M. Rice, professor emeritus. AB, 1970, Dartmouth College; MS, 1972, PhD, 1975, Washington (Seattle). (1977)

Norman M. Savage, professor emeritus. BSc, 1959, Bristol; PhD, 1968, Sydney. (1971)

Harve S. Waff, professor emeritus. BS, 1962, William and Mary; MS, 1966, PhD, 1970, Oregon. (1978)

Daniel Weill, professor emeritus. BA, 1956, Cornell; MS, 1958, Illinois; PhD, 1962, California, Berkeley. (2002)

The date in parentheses at the end of each entry is the first year on the University of Oregon faculty.

- **Bachelor of Arts: Geology Track**
- **Bachelor of Arts: Geophysics Track**
- **Bachelor of Arts: Environmental Geoscience Track**
- **Bachelor of Arts: Paleontology Track**
- **Bachelor of Science: Geology Track**
- **Bachelor of Science: Geophysics Track**
- **Bachelor of Science: Environmental Geoscience Track**
- **Bachelor of Science: Paleontology Track**
- **Minor**

Undergraduate Studies

The undergraduate program in the Department of Earth Sciences provides an understanding of the materials that constitute the earth and the processes that have shaped the earth from deep in its interior to the surface environment—geology. Geology applies all the basic sciences—biology, chemistry, mathematics, and physics—to understanding earth processes in the historical context of geologic time. It is a science that explores problems by combining field investigations with laboratory experiments and theoretical studies.

Geology also addresses many natural hazards—earthquakes, flooding, and volcanic eruptions—that affect humans. It addresses the impact of humans on the earth's surface environment, where we pollute rivers and ground water, cause rapid erosion and landslides, or attempt to re-engineer rivers and shorelines.

Preparation

High school students planning to major in geological sciences should include in their high school program as much mathematics and science (physics, chemistry, biology, or earth science) as possible.

Students who transfer to the department after two years of college work elsewhere should have completed a year of general chemistry, a year of general physics, and two quarters or a semester of calculus. A year of general geology with laboratory is recommended.

Careers

Students with a degree in earth sciences are qualified for employment in a broad range of careers: geotechnical and environmental consultants; K–12 school teachers (with an additional teaching certificate); laboratory technicians; professional geologists, geophysicists, or geochemists; and positions in the petroleum and mining industries or in state and federal agencies such as the United States Geological Survey or the Environmental Protection Agency. The current climate for employment in the earth sciences is good. Geoscience jobs require skills in critical thinking and problem solving, quantitative analysis, oral and written communication, and team work. The Department of Earth Sciences curriculum emphasizes these skills.

Geological Sciences Curriculum

The Department of Earth Sciences offers a bachelor of science (BS) or a bachelor of arts (BA) degree with a major in earth sciences.

Major Tracks

Earth science is an unusually broad subject. It addresses everything from the chemical processes that make rocks and minerals to the physics behind plate tectonics and the travel of earthquake waves through the planet. It explores the history of the evolution of life revealed in fossils, and it probes the earth processes that affect how humans can survive on the surface of the planet. To address this breadth, the department offers four curricular tracks for a major in earth sciences: geology, geophysics, environmental geoscience, and paleontology.

All of the tracks require a common core of general chemistry, calculus, general geology, and physics, except that paleontology- and environmental geoscience–track students may take two terms of biology in place of two terms of physics. Beyond the core, each track requires certain additional courses and a selection of electives.

Undergraduate Research

As many as 4 credits of research can be counted toward electives in any of the tracks. To receive such credit, students must

- submit a short letter, approved by the faculty research advisor and addressed to the head undergraduate advisor in earth sciences, stating the nature of the research and asserting that there is faculty supervision
- submit a final written report to the faculty advisor describing the results of the research

Students may earn credit in this category by registering for any of the following:

Code	Title	Credits
GEOL 401	Research: [Topic]	1-21
GEOL 406	Field Studies: [Topic]	1-6
GEOL 408	Laboratory Projects: [Topic]	1-6

Students who complete an honors thesis may not apply this option toward elective credits.

Grade Options and Standards

Undergraduate majors must take for letter grades (the pass/no pass option is not acceptable) all the courses required in their degree program. Required courses must be completed with grades of C– or better. Exceptions for honors students are noted under Honors in Earth Sciences.

Bachelor of Arts: Geology Track

Code	Title	Credits
Core Courses		
GEOL 101 & GEOL 102 & GEOL 103	Exploring Planet Earth and Exploring Earth's Environment and Exploring Earth History [1]	12
or GEOL 201 & GEOL 202 & GEOL 203	Dynamic Planet Earth and Earth's Surface and Environment and History of Life	
PHYS 201–202	General Physics	8
or PHYS 251 & PHYS 252	Foundations of Physics I and Foundations of Physics I	
CH 221–222	General Chemistry	8
or CH 224H–225H	Honors General Chemistry	

One from the following:		4
CH 223	General Chemistry III	
CH 226H	Honors General Chemistry	
PHYS 203	General Physics	
PHYS 253	Foundations of Physics I	
MATH 246–247	Calculus for the Biological Sciences I-II	8
or MATH 251–252	Calculus I-II	
Select one of the following:		4
MATH 253	Calculus III	
MATH 343	Statistical Models and Methods	
MATH 425	Statistical Methods I	
GEOL 418	Earth and Environmental Data Analysis	
PHYS 481	Design of Experiments	
GEOL 315	Earth Physics	4
GEOL 316	Introduction to Hydrogeology	4
GEOL 318	Introduction to Field Methods	3
Additional Requirements		
GEOL 331	Mineralogy	5
GEOL 332	Introduction to Petrology	5
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 350 & GEOL 351 & GEOL 352	Structural Geology and Structural Geology Problems and Structural Geology Laboratory and Field	5
GEOL 406	Field Studies: [Topic]	12
Electives		
See Electives table for choices		20
Total Credits		106

[1] The 200-level sequence is recommended for majors; however, the 100-level sequence may be substituted if the courses are passed with grades of mid-B or better.

Electives

Code	Title	Credits
Biology		
Courses numbered 306 or higher		
Chemistry		
CH 223	General Chemistry III	4
CH 226H	Honors General Chemistry	4
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 331	Organic Chemistry I	4
CH 335	Organic Chemistry II	4
CH 336	Organic Chemistry III	4
CH 411–413	Physical Chemistry	12
CH 431–433	Inorganic Chemistry	12
CH 444	Chemical Thermodynamics	4
CH 445	Statistical Mechanics	4
Computer and Information Science		
CIS 122	Introduction to Programming and Problem Solving	4
CIS 210–212	Computer Science I-III	12
CIS 315	Intermediate Algorithms	4
Geography		
GEOG 181	Our Digital Earth	4
GEOG 321	Climatology	4
GEOG 322	Geomorphology	4
GEOG 323	Biogeography	4
GEOG 360	Watershed Science and Policy	4
GEOG 361	Global Environmental Change	4
GEOG 421	Advanced Climatology: [Topic]	4
GEOG 423	Advanced Biogeography: [Topic]	4
GEOG 425	Hydrology and Water Resources	4
GEOG 427	Fluvial Geomorphology	4
GEOG 430	Long-Term Environmental Change	4
GEOG 481–482	GIScience I-II	8
GEOG 485–486	Remote Sensing I-II	8
GEOG 491	Advanced Geographic Information Systems	4
GEOG 495	Geographic Data Analysis	4
Earth Sciences		
GEOL 353	Geologic Hazards	4
GEOL 363	MATLAB for Earth Scientists	2
GEOL 401	Research: [Topic]	1-21
GEOL 403	Thesis	1-6
GEOL 410	Experimental Course: [Topic]	5
GEOL 407	Seminar: [Topic] (Current Topics in Geology) [1]	3
Courses higher than 410 [2]		
Mathematics		
MATH 256	Introduction to Differential Equations	4
MATH 281–282	Several-Variable Calculus I-II	8
MATH 341–342	Elementary Linear Algebra	8
MATH 411–412	Functions of a Complex Variable I-II	8
MATH 420	Ordinary Differential Equations	4
MATH 421–422	Partial Differential Equations: Fourier Analysis I-II	8
MATH 425–426	Statistical Methods I-II	8
Physics		
PHYS 203	General Physics	4
or PHYS 253	Foundations of Physics I	
PHYS 204–206	Introductory Physics Laboratory	6
PHYS 290	Foundations of Physics Laboratory	1
PHYS 351–353	Foundations of Physics II	12
PHYS 411–413	Mechanics, Electricity, and Magnetism	12

[1] Pass/no pass

[2] May include one course numbered 304–310.

Bachelor of Science: Geology Track

Code	Title	Credits
Core Courses		
GEOL 101 & GEOL 102 & GEOL 103	Exploring Planet Earth and Exploring Earth's Environment and Exploring Earth History [1]	12

or GEOL 201 & GEOL 202 & GEOL 203	Dynamic Planet Earth and Earth's Surface and Environment and History of Life	
PHYS 201–202	General Physics	8
or PHYS 251 & PHYS 252	Foundations of Physics I and Foundations of Physics I	
CH 221–222	General Chemistry	8
or CH 224H–225H	Honors General Chemistry	
One from the following:		4
CH 223	General Chemistry III	
CH 226H	Honors General Chemistry	
PHYS 203	General Physics	
PHYS 253	Foundations of Physics I	
MATH 246–247	Calculus for the Biological Sciences I-II	8
or MATH 251–252	Calculus I-II	
Select one of the following:		4
MATH 253	Calculus III	
MATH 343	Statistical Models and Methods	
MATH 425	Statistical Methods I	
GEOL 418	Earth and Environmental Data Analysis	
PHYS 481	Design of Experiments	
GEOL 315	Earth Physics	4
GEOL 316	Introduction to Hydrogeology	4
GEOL 318	Introduction to Field Methods	3
Additional Requirements		
GEOL 331	Mineralogy	5
GEOL 332	Introduction to Petrology	5
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 350 & GEOL 351 & GEOL 352	Structural Geology and Structural Geology Problems and Structural Geology Laboratory and Field	5
GEOL 406	Field Studies: [Topic]	12
Electives		
See Electives table for choices		20
Total Credits		106

[1] The 200-level sequence is recommended for majors; however, the 100-level sequence may be substituted if the courses are passed with grades of mid-B or better.

Electives

Code	Title	Credits
Biology		
Courses numbered 306 or higher		
Chemistry		
CH 223	General Chemistry III	4
CH 226H	Honors General Chemistry	4
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 331	Organic Chemistry I	4
CH 335	Organic Chemistry II	4
CH 336	Organic Chemistry III	4
CH 411–413	Physical Chemistry	12
CH 431–433	Inorganic Chemistry	12
CH 444	Chemical Thermodynamics	4
CH 445	Statistical Mechanics	4
Computer and Information Science		
CIS 122	Introduction to Programming and Problem Solving	4
CIS 210–212	Computer Science I-III	12
CIS 315	Intermediate Algorithms	4
Geography		
GEOG 181	Our Digital Earth	4
GEOG 321	Climatology	4
GEOG 322	Geomorphology	4
GEOG 323	Biogeography	4
GEOG 360	Watershed Science and Policy	4
GEOG 361	Global Environmental Change	4
GEOG 421	Advanced Climatology: [Topic]	4
GEOG 423	Advanced Biogeography: [Topic]	4
GEOG 425	Hydrology and Water Resources	4
GEOG 427	Fluvial Geomorphology	4
GEOG 430	Long-Term Environmental Change	4
GEOG 481–482	GIScience I-II	8
GEOG 485–486	Remote Sensing I-II	8
GEOG 491	Advanced Geographic Information Systems	4
GEOG 495	Geographic Data Analysis	4
Earth Sciences		
GEOL 353	Geologic Hazards	4
GEOL 363	MATLAB for Earth Scientists	2
GEOL 401	Research: [Topic]	1-21
GEOL 403	Thesis	1-6
GEOL 410	Experimental Course: [Topic]	5
GEOL 407	Seminar: [Topic] (Current Topics in Geology) [1]	3
Courses higher than 410 [2]		
Mathematics		
MATH 256	Introduction to Differential Equations	4
MATH 281–282	Several-Variable Calculus I-II	8
MATH 341–342	Elementary Linear Algebra	8
MATH 411–412	Functions of a Complex Variable I-II	8
MATH 420	Ordinary Differential Equations	4
MATH 421–422	Partial Differential Equations: Fourier Analysis I-II	8
MATH 425–426	Statistical Methods I-II	8
Physics		
PHYS 203	General Physics	4
or PHYS 253	Foundations of Physics I	
PHYS 204–206	Introductory Physics Laboratory	6
PHYS 290	Foundations of Physics Laboratory	1
PHYS 351–353	Foundations of Physics II	12
PHYS 411–413	Mechanics, Electricity, and Magnetism	12

[1] Pass/no pass

[2] May include one course numbered 304–310.

Bachelor of Arts: Geophysics Track

Code	Title	Credits
GEOL 101 & GEOL 102 & GEOL 103	Exploring Planet Earth and Exploring Earth's Environment and Exploring Earth History [1]	12
or GEOL 201 & GEOL 202 & GEOL 203	Dynamic Planet Earth and Earth's Surface and Environment and History of Life	
CH 221–222	General Chemistry	8
or CH 224H–225H	Honors General Chemistry	
MATH 251–253	Calculus I-III	12
PHYS 251–253	Foundations of Physics I	12
GEOL 315	Earth Physics	4
GEOL 316	Introduction to Hydrogeology	4
GEOL 318	Introduction to Field Methods	3
Additional Requirements		
GEOL 311	Earth Materials	5-10
or GEOL 331 & GEOL 332	Mineralogy and Introduction to Petrology	
GEOL 455	Mechanical Earth	4
MATH 281–282 & MATH 256	Several-Variable Calculus I-II and Introduction to Differential Equations	12
PHYS 351–353	Foundations of Physics II	12
or PHYS 411–413	Mechanics, Electricity, and Magnetism	
Electives		
See Electives table for choices		16
Total Credits		104-109

[1] The 200-level sequence is recommended for majors; however, the 100-level sequence may be substituted if the courses are passed with grades of mid-B or better.

Electives

Code	Title	Credits
Chemistry		
CH 223	General Chemistry III	4
CH 226H	Honors General Chemistry	4
CH 411	Physical Chemistry	4
Earth Sciences		
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 350	Structural Geology	3
GEOL 351	Structural Geology Problems	1
GEOL 352	Structural Geology Laboratory and Field	1
GEOL 353	Geologic Hazards	4
GEOL 363	MATLAB for Earth Scientists	2
GEOL 401	Research: [Topic]	1-21
GEOL 403	Thesis	1-6
GEOL 407	Seminar: [Topic] (Current Topics in Geology) [1]	1-5
Courses numbered 408 or higher		
Mathematics		
MATH 341–342	Elementary Linear Algebra	8
or MATH 421–422	Partial Differential Equations: Fourier Analysis I-II	

[1] Pass/no pass

Bachelor of Science: Geophysics Track

Code	Title	Credits
GEOL 101 & GEOL 102 & GEOL 103	Exploring Planet Earth and Exploring Earth's Environment and Exploring Earth History [1]	12
or GEOL 201 & GEOL 202 & GEOL 203	Dynamic Planet Earth and Earth's Surface and Environment and History of Life	
CH 221–222	General Chemistry	8
or CH 224H–225H	Honors General Chemistry	
MATH 251–253	Calculus I-III	12
PHYS 251–253	Foundations of Physics I	12
GEOL 315	Earth Physics	4
GEOL 316	Introduction to Hydrogeology	4
GEOL 318	Introduction to Field Methods	3
Additional Requirements		
GEOL 311	Earth Materials	5-10
or GEOL 331 & GEOL 332	Mineralogy and Introduction to Petrology	
GEOL 455	Mechanical Earth	4
MATH 281–282 & MATH 256	Several-Variable Calculus I-II and Introduction to Differential Equations	12
PHYS 351–353	Foundations of Physics II	12
or PHYS 411–413	Mechanics, Electricity, and Magnetism	
Electives		
See Electives table for choices		16
Total Credits		104-109

[1] The 200-level sequence is recommended for majors; however, the 100-level sequence may be substituted if the courses are passed with grades of mid-B or better.

Electives

Code	Title	Credits
Chemistry		
CH 223	General Chemistry III	4
CH 226H	Honors General Chemistry	4
CH 411	Physical Chemistry	4
Earth Sciences		
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 350	Structural Geology	3
GEOL 351	Structural Geology Problems	1
GEOL 352	Structural Geology Laboratory and Field	1
GEOL 353	Geologic Hazards	4
GEOL 363	MATLAB for Earth Scientists	2

GEOL 401	Research: [Topic]	1-21
GEOL 403	Thesis	1-6
GEOL 407	Seminar: [Topic] (Current Topics in Geology) [1]	1-5
Courses numbered 408 or higher		
Mathematics		
MATH 341–342	Elementary Linear Algebra	8
or MATH 421–422	Partial Differential Equations: Fourier Analysis I-II	

[1] Pass/no pass

Bachelor of Arts: Environmental Geoscience Track

Code	Title	Credits
Core Courses		
GEOL 101 & GEOL 102 & GEOL 103	Exploring Planet Earth and Exploring Earth's Environment and Exploring Earth History [1]	12
or GEOL 201 & GEOL 202 & GEOL 203	Dynamic Planet Earth and Earth's Surface and Environment and History of Life	
PHYS 201	General Physics	4
or PHYS 251	Foundations of Physics I	
PHYS 202	General Physics	4
or PHYS 252	Foundations of Physics I	
or BI 211	General Biology I: Cells	
Select one of the following:		4
PHYS 203	General Physics	
BI 212	General Biology II: Organisms	
BI 213	General Biology III: Populations	
CH 223	General Chemistry III	
CH 226H	Honors General Chemistry	
PHYS 253	Foundations of Physics I	
CH 221–222	General Chemistry	8
or CH 224H–225H	Honors General Chemistry	
MATH 246–247	Calculus for the Biological Sciences I-II	8
or MATH 251–252	Calculus I-II	
Select one of the following:		4
MATH 253	Calculus III	
MATH 343	Statistical Models and Methods	
MATH 425	Statistical Methods I	
GEOL 418	Earth and Environmental Data Analysis	
PHYS 481	Design of Experiments	
Select two of the following:		10
GEOL 311	Earth Materials	
GEOL 331	Mineralogy	
GEOL 332	Introduction to Petrology	
GEOL 315	Earth Physics	4
GEOL 316	Introduction to Hydrogeology	4
GEOL 318	Introduction to Field Methods	3
Additional Requirements		
GEOL 310	Earth Resources and the Environment	4
GEOG 323	Biogeography	4
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 353	Geologic Hazards	4
BI 370	Ecology	4
or GEOL 451	Hydrogeology	
Electives		
See Electives table for choices		24
Total Credits		109

Electives

Code	Title	Credits
Biology		
BI 212	General Biology II: Organisms	4
BI 213	General Biology III: Populations	4
Courses numbered 306 or higher		
Chemistry		
CH 223	General Chemistry III	4
CH 226H	Honors General Chemistry	4
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 411–413	Physical Chemistry	12
CH 431–433	Inorganic Chemistry	12
CH 444	Chemical Thermodynamics	4
CH 445	Statistical Mechanics	4
Computer and Information Science		
CIS 122	Introduction to Programming and Problem Solving	4
CIS 210–212	Computer Science I-III	12
CIS 315	Intermediate Algorithms	4
Geography		
GEOG 181	Our Digital Earth	4
GEOG 321	Climatology	4
GEOG 322	Geomorphology	4
GEOG 323	Biogeography	4
GEOG 360	Watershed Science and Policy	4
GEOG 361	Global Environmental Change	4
GEOG 421	Advanced Climatology: [Topic]	4
GEOG 423	Advanced Biogeography: [Topic]	4
GEOG 425	Hydrology and Water Resources	4
GEOG 427	Fluvial Geomorphology	4
GEOG 430	Long-Term Environmental Change	4
GEOG 481–482	GIScience I-II	8
GEOG 485–486	Remote Sensing I-II	8
GEOG 491	Advanced Geographic Information Systems	4
GEOG 493	Advanced Cartography	4
GEOG 495	Geographic Data Analysis	4
Earth Sciences		
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 350	Structural Geology	3
GEOL 363	MATLAB for Earth Scientists	2

GEOL 401	Research: [Topic]	1-21
GEOL 403	Thesis	1-6
GEOL 406	Field Studies: [Topic]	1-6
GEOL 410	Experimental Course: [Topic]	5
Courses numbered 411 and higher [2]		
Mathematics		
MATH 256	Introduction to Differential Equations	4
MATH 281–282	Several-Variable Calculus I-II	8
MATH 341–342	Elementary Linear Algebra	8
MATH 411–412	Functions of a Complex Variable I-II	8
MATH 420	Ordinary Differential Equations	4
MATH 421–422	Partial Differential Equations: Fourier Analysis I-II	8
MATH 425–426	Statistical Methods I-II	8
Physics		
PHYS 203	General Physics	4
PHYS 204–206	Introductory Physics Laboratory	6
PHYS 253	Foundations of Physics I	4
PHYS 290	Foundations of Physics Laboratory	1
PHYS 351–353	Foundations of Physics II	12
PHYS 411–413	Mechanics, Electricity, and Magnetism	12
Engineering		
Oregon State University engineering courses, by permission of a departmental advisor		

1 The 200-level sequence is recommended for majors; however, the 100-level sequence may be substituted if the courses are passed with grades of mid-B or better.

2 May include courses numbered 304-310.

Bachelor of Science: Environmental Geoscience Track

Code	Title	Credits
Core Courses		
GEOL 101 & GEOL 102 & GEOL 103	Exploring Planet Earth and Exploring Earth's Environment and Exploring Earth History [1]	12
or GEOL 201 & GEOL 202 & GEOL 203	Dynamic Planet Earth and Earth's Surface and Environment and History of Life	
PHYS 201	General Physics	4
or PHYS 251	Foundations of Physics I	
PHYS 202	General Physics	4
or PHYS 252	Foundations of Physics I	
or BI 211	General Biology I: Cells	
Select one of the following:		4
PHYS 203	General Physics	
BI 212	General Biology II: Organisms	
BI 213	General Biology III: Populations	
CH 223	General Chemistry III	
CH 226H	Honors General Chemistry	
PHYS 253	Foundations of Physics I	
CH 221–222	General Chemistry	8
or CH 224H–225H	Honors General Chemistry	
MATH 246–247	Calculus for the Biological Sciences I-II	8
or MATH 251–252	Calculus I-II	
Select one of the following:		4
MATH 253	Calculus III	
MATH 343	Statistical Models and Methods	
MATH 425	Statistical Methods I	
GEOL 418	Earth and Environmental Data Analysis	
PHYS 481	Design of Experiments	
Select two of the following:		10
GEOL 311	Earth Materials	
GEOL 331	Mineralogy	
GEOL 332	Introduction to Petrology	
GEOL 315	Earth Physics	4
GEOL 316	Introduction to Hydrogeology	4
GEOL 318	Introduction to Field Methods	3
Additional Requirements		
GEOL 310	Earth Resources and the Environment	4
GEOG 323	Biogeography	4
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 353	Geologic Hazards	4
BI 370	Ecology	4
or GEOL 451	Hydrogeology	
Electives		
See Electives table for choices		24
Total Credits		109

Electives

Code	Title	Credits
Biology		
BI 212	General Biology II: Organisms	4
BI 213	General Biology III: Populations	4
Courses numbered 306 or higher		
Chemistry		
CH 223	General Chemistry III	4
CH 226H	Honors General Chemistry	4
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 411–413	Physical Chemistry	12
CH 431–433	Inorganic Chemistry	12
CH 444	Chemical Thermodynamics	4
CH 445	Statistical Mechanics	4
Computer and Information Science		
CIS 122	Introduction to Programming and Problem Solving	4
CIS 210–212	Computer Science I-III	12
CIS 315	Intermediate Algorithms	4
Geography		
GEOG 181	Our Digital Earth	4
GEOG 321	Climatology	4

GEOG 322	Geomorphology	4
GEOG 323	Biogeography	4
GEOG 360	Watershed Science and Policy	4
GEOG 361	Global Environmental Change	4
GEOG 421	Advanced Climatology: [Topic]	4
GEOG 423	Advanced Biogeography: [Topic]	4
GEOG 425	Hydrology and Water Resources	4
GEOG 427	Fluvial Geomorphology	4
GEOG 430	Long-Term Environmental Change	4
GEOG 481–482	GIScience I-II	8
GEOG 485–486	Remote Sensing I-II	8
GEOG 491	Advanced Geographic Information Systems	4
GEOG 493	Advanced Cartography	4
GEOG 495	Geographic Data Analysis	4
Earth Sciences		
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 350	Structural Geology	3
GEOL 363	MATLAB for Earth Scientists	2
GEOL 401	Research: [Topic]	1-21
GEOL 403	Thesis	1-6
GEOL 406	Field Studies: [Topic]	1-6
GEOL 410	Experimental Course: [Topic]	5
Courses numbered 411 and higher [2]		
Mathematics		
MATH 256	Introduction to Differential Equations	4
MATH 281–282	Several-Variable Calculus I-II	8
MATH 341–342	Elementary Linear Algebra	8
MATH 411–412	Functions of a Complex Variable I-II	8
MATH 420	Ordinary Differential Equations	4
MATH 421–422	Partial Differential Equations: Fourier Analysis I-II	8
MATH 425–426	Statistical Methods I-II	8
Physics		
PHYS 203	General Physics	4
PHYS 204–206	Introductory Physics Laboratory	6
PHYS 253	Foundations of Physics I	4
PHYS 290	Foundations of Physics Laboratory	1
PHYS 351–353	Foundations of Physics II	12
PHYS 411–413	Mechanics, Electricity, and Magnetism	12
Engineering		
Oregon State University engineering courses, by permission of a departmental advisor		

1 The 200-level sequence is recommended for majors; however, the 100-level sequence may be substituted if the courses are passed with grades of mid-B or better.

2 May include courses numbered 304-310.

Bachelor of Arts: Paleontology Track

Code	Title	Credits
GEOL 101 & GEOL 102 & GEOL 103	Exploring Planet Earth and Exploring Earth's Environment and Exploring Earth History [1]	12
or GEOL 201 & GEOL 202 & GEOL 203	Dynamic Planet Earth and Earth's Surface and Environment and History of Life	
PHYS 201	General Physics	4
or PHYS 251	Foundations of Physics I	
Select one of the following:		8
BI 211–213	General Biology I-III	
PHYS 202–203	General Physics	
PHYS 252–253	Foundations of Physics I	
CH 221–223	General Chemistry	12
or CH 224H–226H	Honors General Chemistry	
MATH 246–247	Calculus for the Biological Sciences I-II	8
or MATH 251–252	Calculus I-II	
Select one of the following:		4
MATH 253	Calculus III	
MATH 343	Statistical Models and Methods	
MATH 425	Statistical Methods I	
GEOL 418	Earth and Environmental Data Analysis	
PHYS 481	Design of Experiments	
GEOL 311	Earth Materials	5-10
or GEOL 331 & GEOL 332	Mineralogy and Introduction to Petrology	
GEOL 315	Earth Physics	4
or GEOL 316	Introduction to Hydrogeology	
GEOL 318	Introduction to Field Methods	3
Additional Requirements		
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 350 & GEOL 351 & GEOL 352	Structural Geology and Structural Geology Problems and Structural Geology Laboratory and Field	5
GEOL 406	Field Studies: [Topic]	12
Select two of the following:		8
GEOL 431	Paleontology I: Paleozoic Marine Fossils	
GEOL 433	Paleobotany	
GEOL 434	Vertebrate Paleontology	
GEOL 435	Paleopedology	
Electives		
See Electives table for choices		16
Total Credits		105-110

1 The 200-level sequence is recommended for majors; however, the 100-level sequence may be substituted if the courses are passed with grades of mid-B or better.

Electives

Code	Title	Credits
Anthropology		
ANTH 361	Human Evolution	4
ANTH 366	Human Osteology Laboratory	4
ANTH 466	Primate Feeding and Nutrition	4

ANTH 468	Evolutionary Theory	4
ANTH 471	Zooarchaeology: [Topic]	4
Biology		
Courses numbered 306 or higher		
Chemistry		
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 223	General Chemistry III	4
CH 331,335–336	Organic Chemistry I-III	12
CH 411–413	Physical Chemistry	12
CH 431–433	Inorganic Chemistry	12
CH 444	Chemical Thermodynamics	4
CH 445	Statistical Mechanics	4
Computer and Information Science		
CIS 122	Introduction to Programming and Problem Solving	4
CIS 210–212	Computer Science I-III	12
CIS 315	Intermediate Algorithms	4
Geography		
GEOG 181	Our Digital Earth	4
GEOG 321	Climatology	4
GEOG 322	Geomorphology	4
GEOG 323	Biogeography	4
GEOG 360	Watershed Science and Policy	4
GEOG 361	Global Environmental Change	4
GEOG 421	Advanced Climatology: [Topic]	4
GEOG 423	Advanced Biogeography: [Topic]	4
GEOG 425	Hydrology and Water Resources	4
GEOG 427	Fluvial Geomorphology	4
GEOG 430	Long-Term Environmental Change	4
GEOG 481–482	GIScience I-II	8
GEOG 495	Geographic Data Analysis	4
Earth Sciences		
GEOL 315	Earth Physics	4
GEOL 316	Introduction to Hydrogeology	4
GEOL 353	Geologic Hazards	4
GEOL 363	MATLAB for Earth Scientists	2
GEOL 401	Research: [Topic]	1-21
GEOL 403	Thesis	1-6
GEOL 410	Experimental Course: [Topic]	5
GEOL 407	Seminar: [Topic] [1]	3
Courses higher than 410 [2]		
Mathematics		
MATH 256	Introduction to Differential Equations	4
MATH 281–282	Several-Variable Calculus I-II	8
MATH 341–342	Elementary Linear Algebra	8
MATH 411–412	Functions of a Complex Variable I-II	8
MATH 420	Ordinary Differential Equations	4
MATH 425–426	Statistical Methods I-II	8
Physics		
PHYS 204–206	Introductory Physics Laboratory	6
PHYS 290	Foundations of Physics Laboratory	1
PHYS 351–353	Foundations of Physics II	12
PHYS 411–413	Mechanics, Electricity, and Magnetism	12

1 Pass/no pass

2 May include one course numbered 304–310.

Bachelor of Science: Paleontology Track

Code	Title	Credits
GEOL 101 & GEOL 102 & GEOL 103	Exploring Planet Earth and Exploring Earth's Environment and Exploring Earth History [1]	12
or GEOL 201 & GEOL 202 & GEOL 203	Dynamic Planet Earth and Earth's Surface and Environment and History of Life	
PHYS 201	General Physics	4
or PHYS 251	Foundations of Physics I	
Select one of the following:		8
BI 211–213	General Biology I-III	
PHYS 202–203	General Physics	
PHYS 252–253	Foundations of Physics I	
CH 221–223	General Chemistry	12
or CH 224H–226H	Honors General Chemistry	
MATH 246–247	Calculus for the Biological Sciences I-II	8
or MATH 251–252	Calculus I-II	
Select one of the following:		4
MATH 253	Calculus III	
MATH 343	Statistical Models and Methods	
MATH 425	Statistical Methods I	
GEOL 418	Earth and Environmental Data Analysis	
PHYS 481	Design of Experiments	
GEOL 311	Earth Materials	5-10
or GEOL 331 & GEOL 332	Mineralogy and Introduction to Petrology	
GEOL 315	Earth Physics	4
or GEOL 316	Introduction to Hydrogeology	
GEOL 318	Introduction to Field Methods	3
Additional Requirements		
GEOL 334	Sedimentology and Stratigraphy	4
GEOL 350 & GEOL 351 & GEOL 352	Structural Geology and Structural Geology Problems and Structural Geology Laboratory and Field	5
GEOL 406	Field Studies: [Topic]	12
Select two of the following:		8
GEOL 431	Paleontology I: Paleozoic Marine Fossils	
GEOL 433	Paleobotany	
GEOL 434	Vertebrate Paleontology	
GEOL 435	Paleopedology	
Electives		

See Electives table for choices	16
Total Credits	105-110

[1] The 200-level sequence is recommended for majors; however, the 100-level sequence may be substituted if the courses are passed with grades of mid-B or better.

Electives

Code	Title	Credits
Anthropology		
ANTH 361	Human Evolution	4
ANTH 366	Human Osteology Laboratory	4
ANTH 466	Primate Feeding and Nutrition	4
ANTH 468	Evolutionary Theory	4
ANTH 471	Zooarchaeology: [Topic]	4
Biology		
Courses numbered 306 or higher		
Chemistry		
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 223	General Chemistry III	4
CH 331,335–336	Organic Chemistry I-III	12
CH 411–413	Physical Chemistry	12
CH 431–433	Inorganic Chemistry	12
CH 444	Chemical Thermodynamics	4
CH 445	Statistical Mechanics	4
Computer and Information Science		
CIS 122	Introduction to Programming and Problem Solving	4
CIS 210–212	Computer Science I-III	12
CIS 315	Intermediate Algorithms	4
Geography		
GEOG 181	Our Digital Earth	4
GEOG 321	Climatology	4
GEOG 322	Geomorphology	4
GEOG 323	Biogeography	4
GEOG 360	Watershed Science and Policy	4
GEOG 361	Global Environmental Change	4
GEOG 421	Advanced Climatology: [Topic]	4
GEOG 423	Advanced Biogeography: [Topic]	4
GEOG 425	Hydrology and Water Resources	4
GEOG 427	Fluvial Geomorphology	4
GEOG 430	Long-Term Environmental Change	4
GEOG 481–482	GIScience I-II	8
GEOG 495	Geographic Data Analysis	4
Earth Sciences		
GEOL 315	Earth Physics	4
GEOL 316	Introduction to Hydrogeology	4
GEOL 353	Geologic Hazards	4
GEOL 363	MATLAB for Earth Scientists	2
GEOL 401	Research: [Topic]	1-21
GEOL 403	Thesis	1-6
GEOL 410	Experimental Course: [Topic]	5
GEOL 407	Seminar: [Topic] [1]	3
Courses higher than 410 [2]		
Mathematics		
MATH 256	Introduction to Differential Equations	4
MATH 281–282	Several-Variable Calculus I-II	8
MATH 341–342	Elementary Linear Algebra	8
MATH 411–412	Functions of a Complex Variable I-II	8
MATH 420	Ordinary Differential Equations	4
MATH 425–426	Statistical Methods I-II	8
Physics		
PHYS 204–206	Introductory Physics Laboratory	6
PHYS 290	Foundations of Physics Laboratory	1
PHYS 351–353	Foundations of Physics II	12
PHYS 411–413	Mechanics, Electricity, and Magnetism	12

[1] Pass/no pass

[2] May include one course numbered 304–310.

Honors in Earth Sciences

Application for graduation with honors in earth sciences must be made no later than spring term of the student's junior year. To be eligible for graduation with honors, a student must

- maintain a grade point average (GPA) of 3.50 or better in geological sciences courses or a 3.00 or better in all science courses
- submit and orally present an acceptable honors thesis written under the supervision of a department faculty member and evaluated by a committee consisting of three faculty members including the supervisor. The thesis should be presented no later than three weeks before final examinations during the term the student plans to graduate

Honors students may register for 3 credits of Research: [Topic] (GEOL 401) the term before they intend to graduate, and 3 credits of Thesis (GEOL 403) the term of graduation. These credits may be applied toward electives.

Minor Requirements

Code	Title	Credits
GEOL 101 & GEOL 102 & GEOL 103	Exploring Planet Earth and Exploring Earth's Environment and Exploring Earth History	12
or GEOL 201 & GEOL 202 & GEOL 203	Dynamic Planet Earth and Earth's Surface and Environment and History of Life	
Choose from the following courses: [1]		15
GEOL 213	Geology of National Parks	
GEOL 300-499-499		
Total Credits		27

[1] 15 credits of earth sciences courses (exclusive of independent study courses) must be earned with course numbers greater than GEOL 299 (GEOL 213 is acceptable, however). No more than 8 credits may be applied to the minor from the following list: Geology of National Parks (GEOL 213), The Fossil Record (GEOL 304), Dinosaurs (GEOL 305), Volcanoes and Earthquakes (GEOL 306), Oceanography (GEOL 307), Geology of Oregon and the Pacific Northwest (GEOL 308), Earth Resources and the Environment (GEOL 310).

Undergraduate minors must take all required courses for letter grades and complete them with grades of C– or better.

Group Requirements

Fourteen earth sciences courses satisfy university science group requirements. See the Group Requirements section of this catalog under **Registration and Academic Policies.**

Kindergarten through Secondary Teaching Careers

Students who complete a degree with a major in earth sciences are eligible to apply to the College of Education's fifth-year licensure program in middle-secondary teaching or the fifth-year licensure program in elementary teaching. More information is available in the College of Education (http://catalog.uoregon.edu/archive/2018-2019/education) section of this catalog.

Four-Year Degree Plan

The degree plan shown is only a sample of how students may complete their degrees in four years. There are alternative ways. Students should consult their advisor to determine the best path for them.

- **Geology Track** (p.)
- **Geophysics Track** (p.)
- **Environmental Geoscience Track** (p.)
- **Paleontology Track** (p.)

Bachelor of Science in Earth Sciences: Geology Track

Course	Title		Credits	Milestones
First Year				
Fall				
GEOL 101 or GEOL 201	Exploring Planet Earth or Dynamic Planet Earth	200-level courses recommended for majors; 100-level requires a grade of mid-B or better	4	
MATH 111	College Algebra		4	
WR 121	College Composition I		4	
CH 221 or CH 224H	General Chemistry I or Honors General Chemistry		4	
	Credits		16	
Winter				
GEOL 102 or GEOL 202	Exploring Earth's Environment or Earth's Surface and Environment	200-level courses recommen for majors; 100-level requires a grade of mid-B or better	4	
MATH 112	Elementary Functions		4	
CH 222 or CH 225H	General Chemistry II or Honors General Chemistry		4	
General-education, multicultural, or other group-satisfying course			4	
	Credits		16	
Spring				
GEOL 103 or GEOL 203	Exploring Earth History or History of Life	200-level courses recommended for majors; 100-level requires a grade of mid-B or better	4	
WR 122 or WR 123	College Composition II or College Composition III		4	
MATH 246 or MATH 251	Calculus for the Biological Sciences I or Calculus I		4	
General-education, multicultural, or other group-satisfying course			4	
	Credits		16	
	Total Credits		48	

Course	Title		Credits	Milestones
Second Year				
Fall				
PHYS 201 or PHYS 251	General Physics or Foundations of Physics I		4	
MATH 247 or MATH 252	Calculus for the Biological Sciences II or Calculus II		4	
GEOL 331	Mineralogy	Could substitute GEOL 311 (spring term) for GEOL 331 and 332	5	

General-education, multicultural, or other group-satisfying course			4
	Credits		17
Winter			
PHYS 202 or PHYS 252	General Physics or Foundations of Physics I		4
GEOL 315	Earth Physics		4
GEOL 332	Introduction to Petrology	Could substitute GEOL 311 (spring term) for GEOL 331 and 332	5
General-education, multicultural, or other group-satisfying course			4
	Credits		17
Spring			
PHYS 203 or PHYS 253 or CH 223 or CH 226H	General Physics or Foundations of Physics I or General Chemistry III or Honors General Chemistry		4
GEOL 318	Introduction to Field Methods		3
GEOL 316	Introduction to Hydrogeology		4
General-education, multicultural, or other group-satisfying course			4
	Credits		15
	Total Credits		49

Course	Title		Credits Milestones
Third Year			
Fall			
GEOL 418 or MATH 253 or MATH 343 or MATH 425 or PHYS 481	Earth and Environmental Data Analysis or Calculus III or Statistical Models and Methods or Statistical Methods I or Design of Experiments	GEOL 418 is preferred, to be taken any term in the third year	4
General-education, multicultural, or other group-satisfying courses			8
Geology elective			4
	Credits		16
Winter			
General-education, multicultural, or other group-satisfying courses			8
Geology elective			4
	Credits		12
Spring			
GEOL 334	Sedimentology and Stratigraphy		4
GEOL 350	Structural Geology		3
GEOL 351	Structural Geology Problems		1
GEOL 352	Structural Geology Laboratory and Field		1
General-education, multicultural, or other group-satisfying course			4
	Credits		13
Summer			
GEOL 406	Field Studies: [Topic]	Each section of these three courses is two weeks; could also be taken after the fourth year	12
	Credits		12
	Total Credits		53

Course	Title	Credits Milestones
Fourth Year		
Fall		
General-education, multicultural, or other group-satisfying courses		8
Geology or other science elective		4
	Credits	12
Winter		
General-education, multicultural, or other group-satisfying courses		8
Geology or other science elective		4
	Credits	12
Spring		
General-education, multicultural, or other group-satisfying courses		8
Geology or other science elective		4
	Credits	12
	Total Credits	36

Bachelor of Science in Earth Sciences: Geophysics Track

Course	Title		Credits Milestones
First Year			
Fall			
GEOL 101 or GEOL 201	Exploring Planet Earth or Dynamic Planet Earth	200-level courses recommended for majors; 100-level requires a grade of mid-B or better	4
MATH 111	College Algebra		4
WR 121	College Composition I		4
CH 221 or CH 224H	General Chemistry I or Honors General Chemistry		4
	Credits		16
Winter			
GEOL 102 or GEOL 202	Exploring Earth's Environment or Earth's Surface and Environment	200-level courses recommen for majors; 100-level requires a grade of mid-B or better	4
MATH 112	Elementary Functions		4
CH 222 or CH 225H	General Chemistry II or Honors General Chemistry		4
General-education, multicultural, or other group-satisfying course			4
	Credits		16
Spring			
GEOL 103 or GEOL 203	Exploring Earth History or History of Life	200-level courses recommended for majors; 100-level requires a grade of mid-B or better	4
WR 122 or WR 123	College Composition II or College Composition III		4
MATH 246 or MATH 251	Calculus for the Biological Sciences I or Calculus I		4
General-education, multicultural, or other group-satisfying course			4
	Credits		16
	Total Credits		48

Course	Title		Credits Milestones
Second Year			
Fall			
PHYS 251	Foundations of Physics I	Pre- or corequisite: MATH 251	4
MATH 252	Calculus II		4
GEOL 318	Introduction to Field Methods		3
General-education, multicultural, or other group-satisfying course			4
	Credits		15
Winter			
PHYS 252	Foundations of Physics I	Pre- or corequisite MATH 252	4
MATH 253	Calculus III		4
GEOL 315	Earth Physics		4
General-education, multicultural, or other group-satisfying course			4
	Credits		16
Spring			
PHYS 253	Foundations of Physics I	Pre- or corequisite: MATH 253	4
GEOL 311	Earth Materials	Could substitute GEOL 331 (fall term) and GEOL 332 (winter) for GEOL 311, for more in-depth exposure to same material	5
GEOL 316	Introduction to Hydrogeology		4
General-education, multicultural, or other group-satisfying course			4
	Credits		17
	Total Credits		48

Course	Title	Credits Milestones
Third Year		
Fall		
MATH 256	Introduction to Differential Equations	4

PHYS 351	Foundations of Physics II	Could substitute PHYS 411	4
General-education, multicultural, or other group-satisfying course			4
	Credits		12
Winter			
MATH 281	Several-Variable Calculus I		4
PHYS 352	Foundations of Physics II	Could substitute PHYS 412	4
GEOL 455	Mechanical Earth		4
	Credits		12
Spring			
MATH 282	Several-Variable Calculus II		4
PHYS 353	Foundations of Physics II	Could substitute PHYS 413	4
Geology or other science elective		GEOL 318 recommended	4
	Credits		12
	Total Credits		36

Course	Title	Credits	Milestones
Fourth Year			
Fall			
General-education, multicultural, or other group-satisfying courses			4
Geology or other science elective			8
	Credits		12
Winter			
General-education, multicultural, or other group-satisfying courses			8
Geology or other science elective			4
	Credits		12
Spring			
General-education, multicultural, or other group-satisfying courses			8
Geology or other science elective			4
	Credits		12
	Total Credits		36

Bachelor of Science in Earth Sciences: Environmental Geoscience Track

Course	Title	Credits	Milestones
First Year			
Fall			
GEOL 101 or GEOL 201	Exploring Planet Earth or Dynamic Planet Earth	200-level courses recommended for majors; 100-level requires a grade of mid-B or better	4
MATH 111	College Algebra		4
WR 121	College Composition I		4
CH 221 or CH 224H	General Chemistry I or Honors General Chemistry		4
	Credits		16
Winter			
GEOL 102 or GEOL 202	Exploring Earth's Environment or Earth's Surface and Environment	200-level courses recommen for majors; 100-level requires a grade of mid-B or better	4
MATH 112	Elementary Functions		4
CH 222 or CH 225H	General Chemistry II or Honors General Chemistry		4
General-education, multicultural, or other group-satisfying course			4
	Credits		16
Spring			
GEOL 103 or GEOL 203	Exploring Earth History or History of Life	200-level courses recommended for majors; 100-level requires a grade of mid-B or better	4
WR 122 or WR 123	College Composition II or College Composition III		4
MATH 246 or MATH 251	Calculus for the Biological Sciences I or Calculus I		4

General-education, multicultural, or other group-satisfying course			4
	Credits		16
	Total Credits		48

Course	Title		Credits	Milestones
Second Year				
Fall				
PHYS 201 or PHYS 251	General Physics or Foundations of Physics I		4	
MATH 247 or MATH 252	Calculus for the Biological Sciences II or Calculus II		4	
GEOL 331	Mineralogy	Could substitute GEOL 311 (spring term) for GEOL 331 and 332	5	
Geology elective			4	
	Credits		17	
Winter				
PHYS 202 or BI 211	General Physics or General Biology I: Cells	Could replace with PHYS 252	4	
GEOL 315	Earth Physics		4	
GEOL 332	Introduction to Petrology	Could substitute GEOL 311 (spring term) for GEOL 331 and 332	5	
General-education, multicultural, or other group-satisfying course			4	
	Credits		17	
Spring				
PHYS 203 or PHYS 253 or BI 212 or BI 213 or CH 223 or CH 226H	General Physics or Foundations of Physics I or General Biology II: Organisms or General Biology III: Populations or General Chemistry III or Honors General Chemistry		4	
GEOL 311	Earth Materials	Could substitute GEOL 331 (fall term) and GEOL 332 (winter) for GEOL 311	5	
GEOL 316	Introduction to Hydrogeology		4	
General-education, multicultural, or other group-satisfying course			4	
	Credits		17	
	Total Credits		51	

Course	Title		Credits	Milestones
Third Year				
Fall				
GEOL 310	Earth Resources and the Environment		4	
GEOL 318	Introduction to Field Methods	Option: Take GEOL 318 spring term and enroll in a geology elective instead	3	
General-education, multicultural, or other group-satisfying courses			8	
	Credits		15	
Winter				
GEOL 353	Geologic Hazards		4	
GEOL 451	Hydrogeology		4	
GEOL 418 or MATH 253 or MATH 343 or MATH 425 or PHYS 481	Earth and Environmental Data Analysis or Calculus III or Statistical Models and Methods or Statistical Methods I or Design of Experiments	GEOL 418 preferred, taken in any term this year	4	
General-education, multicultural, or other group-satisfying course			4	
	Credits		16	
Spring				
GEOL 334	Sedimentology and Stratigraphy		4	
GEOG 323	Biogeography		4	
General-education, multicultural, or other group-satisfying course			4	

Geology elective		GEOL 318 recommended	4
	Credits		16
	Total Credits		47

Course	Title	Credits	Milestones
Fourth Year			
Fall			
General-education, multicultural, or other group-satisfying courses			8
Geology or other science elective			8
	Credits		16
Winter			
General-education, multicultural, or other group-satisfying courses			8
Geology or other science elective			8
	Credits		16
Spring			
General-education, multicultural, or other group-satisfying courses			12
Geology or other science elective			4
	Credits		16
	Total Credits		48

Bachelor of Science in Earth Sciences: Paleontology Track

Course	Title	Credits	Milestones
First Year			
Fall			
GEOL 101 or GEOL 201	Exploring Planet Earth or Dynamic Planet Earth	200-level courses recommended for majors; 100-level requires a grade of mid-B or better	4
MATH 111	College Algebra		4
WR 121	College Composition I		4
CH 221 or CH 224H	General Chemistry I or Honors General Chemistry		4
	Credits		16
Winter			
GEOL 102 or GEOL 202	Exploring Earth's Environment or Earth's Surface and Environment	200-level courses recommen for majors; 100-level requires a grade of mid-B or better	4
MATH 112	Elementary Functions		4
CH 222 or CH 225H	General Chemistry II or Honors General Chemistry		4
General-education, multicultural, or other group-satisfying course			4
	Credits		16
Spring			
GEOL 103 or GEOL 203	Exploring Earth History or History of Life	200-level courses recommended for majors; 100-level requires a grade of mid-B or better	4
WR 122 or WR 123	College Composition II or College Composition III		4
CH 223 or CH 226H	General Chemistry III or Honors General Chemistry		4
MATH 251	Calculus I	Could substitute MATH 246	4
	Credits		16
	Total Credits		48

Course	Title	Credits	Milestones
Second Year			
Fall			
PHYS 201 or PHYS 251	General Physics or Foundations of Physics I		4
BI 211	General Biology I: Cells		4
MATH 252	Calculus II	Could substitute MATH 247	4

GEOL 331	Mineralogy	Could substitute GEOL 311 (spring term) for GEOL 331 and 332	5
	Credits		17
Winter			
PHYS 202	General Physics	Could replace with PHYS 252	4
GEOL 315 or GEOL 316	Earth Physics or Introduction to Hydrogeology		4
GEOL 332	Introduction to Petrology	Could substitute GEOL 311 (spring term) for GEOL 331 and 332	5
General-education, multicultural, or other group-satisfying course			4
	Credits		17
Spring			
PHYS 203	General Physics	Could replace with PHYS 253	4
GEOL 318	Introduction to Field Methods		3
General-education, multicultural, or other group-satisfying course			8
	Credits		15
	Total Credits		49

Course	Title	Credits	Milestones
Third Year			
Fall			
Choose one from the following:			
GEOL 431	Paleontology I: Paleozoic Marine Fossils		
GEOL 433	Paleobotany		
GEOL 434	Vertebrate Paleontology		
GEOL 435	Paleopedology		
General-education, multicultural, or other group-satisfying courses			
Geology or other science elective			
	Credits		
Winter			
Choose one from the following:			
GEOL 431	Paleontology I: Paleozoic Marine Fossils		
GEOL 433	Paleobotany		
GEOL 434	Vertebrate Paleontology		
GEOL 435	Paleopedology		
General-education, multicultural, or other group-satisfying courses			
Geology or other science course			
	Credits		
Spring			
GEOL 334	Sedimentology and Stratigraphy	4	
GEOL 350	Structural Geology	3	
GEOL 351	Structural Geology Problems	1	

These courses are typically offered in alternate years, so enrollment is necessary in the third or fourth year according to availability. Contact advisor or department office for scheduling of these courses. 4

These courses are typically offered in alternate years, so enrollment is necessary in the third or fourth year according to availability. Contact advisor or department office for scheduling of these courses. 4

GEOL 352	Structural Geology Laboratory and Field		1
General-education, multicultural, or other group-satisfying course			4
	Credits		13
Summer			
GEOL 406	Field Studies: [Topic]	Each section of these three courses is two weeks; could also be taken after the fourth year	12
	Credits		12
	Total Credits		49

Course	Title	Credits	Milestones
Fourth Year			
Fall			
General-education, multicultural, or other group-satisfying courses		8	
Geology or other science elective		8	
	Credits	16	
Winter			
General-education, multicultural, or other group-satisfying courses		8	
Geology or other science elective		8	
	Credits	16	
Spring			
General-education, multicultural, or other group-satisfying courses		12	
Geology or other science elective		4	
	Credits	16	
	Total Credits	48	

Graduate Studies

The Department of Earth Sciences offers programs of graduate study leading to master of science (MS), master of arts (MA), and doctor of philosophy (PhD) degrees with opportunity for research in a wide variety of specialty fields. Course work is designed to meet individual needs, and students may pursue independent research in geobiology, geochemistry, geodesy, geomechanics, geomorphology, geophysics, mineralogy, petrology, volcanology, paleontology, stratigraphy, sedimentary petrology, structural geology, and ore deposit geology. The master's degree program requires two years or more for completion.

Admission to the graduate program is competitive and based on academic records, scores on the Graduate Record Examinations (GRE), and letters of recommendation. Nonnative speakers of English must also submit scores for the Test of English as a Foreign Language (TOEFL) and the Test of Spoken English (TSE). Applications are welcome from students who are interested in using their background in related fields, such as physics, chemistry, and biology, to solve geologic or geophysical problems.

Graduate students are advised by a guidance committee consisting of three faculty members. This committee meets with each student shortly after he or she arrives on campus and as often thereafter as necessary for planning purposes.

Requirements

Basic university requirements for graduate degrees are described in the Graduate School (http://catalog.uoregon.edu/archive/2018-2019/graduate) section of this catalog. The department sets additional examination, course work, seminar, and thesis requirements. Applicants should read the *Guide to Graduate Study* on the department website (http://earthsciences.uoregon.edu/graduate-program) or write to the Department of Earth Sciences for details.

Programs

Graduate study in earth sciences is offered in five broad areas:

1. volcanology-petrology-geochemistry
2. stratigraphy–surface processes
3. paleontology-paleopedology-geobiology
4. structural geology–geophysics
5. economic geology (mineral deposits)

Volcanology-Petrology-Geochemistry

The department has excellent analytical and other research facilities for studies in these subdisciplines, and the volcanic and metamorphic terrane of the Northwest offers unsurpassed opportunities for field studies. Active research programs are diverse and include studies of eruption dynamics, magma volatile inventories, and magma rheology; experimental studies of igneous phase equilibria and trace element partitioning; calculations of multicomponent equilibria in aqueous systems and volcanic gases; and studies of igneous protogenesis.

Stratigraphy–Surface Processes

The stratigraphic record of tectonically active sedimentary basins indicates the dynamic interactions among basin subsidence, sediment input from eroding sources, evolution of depositional systems, and active faulting and folding that govern these processes. Research in this area combines field-based stratigraphic, sedimentologic, and geomorphic analysis with provenance studies and concepts derived from theoretical models to decipher the complex structural and climatic controls on the filling histories of active basins.

Surface processes regulate how tectonics and climate affect landscape evolution. Field observations, numerical simulations, topographic analyses, and experimental facilities are used to study sediment transport processes over a range of spatial and temporal scales. Projects incorporate links between active tectonics and structural geology, biology, geomechanics, and surface processes to address problems such as landsliding and hill-slope evolution, biological contributions to soil creep and landscape lowering, and the geomorphic implications of seismic-induced landsliding.

Paleontology-Paleopedology-Geobiology

Studies of fossil soils, plants, and vertebrates aim to reconstruct life on land and its role in global change. Global changes of interest include Neogene paleoclimate and paleoenvironment of ape and human evolution in East Africa, environmental effects of terminal Cretaceous

impact and dinosaur extinction in Montana, consequences of mass extinction and methane clathrate degassing at the Permian-Triassic boundary, and the effect of early land plants and forests on weathering and atmospheric composition during the early Paleozoic.

Geobiology focuses on the interaction of microorganisms with the geologic environment and the ways life forms affect geological processes, such as weathering and mineralization.

Structural Geology–Geophysics

Graduate work in the structural geology–geophysics area involves the study of the earth's dynamic processes.

Seismic imaging techniques using regional arrays provide tools for understanding regional tectonics. Studies of upper-mantle and lithospheric structure beneath the Rocky Mountains and in the Pacific Northwest subduction zone are providing essential constraints, unavailable from surface geology, for detailed dynamical models of plate-lithospheric deformation.

Structural geology focuses on applying modern field and analytical techniques to solving problems in Cenozoic tectonics and active faulting. Detailed field mapping, trench logging, and geomorphic analysis are combined with seismic array data, land- and space-based geodetic data, and theoretical modeling to address problems including Oregon's Basin and Range province and coastal deformation, active tectonics of the San Andreas Fault system, and seismic risk along the Pacific margin of the United States and southeast and central Asia.

Geophysical experiments conducted at sea investigate the nature of sea-floor spreading including the segregation, transport, and storage of melt; the rifting of oceanic lithosphere; and the spatial and temporal connectivity between magmatic, tectonic, and hydrothermal processes.

Mineral Deposits

Current research on ore deposits includes studies of porphyry copper deposits, epithermal veins, and active geothermal systems. These projects combine field mapping, petrography, and chemical analyses with theoretical chemical modeling of processes of ore fluid generation, alteration, and mineralization.

Related Research Activities

The Condon Collection of Fossils at the Museum of Natural and Cultural History maintains strong ties to the Department of Earth Sciences. Two geology professors are curators of the collection, and paleontology undergraduate and graduate students are often employed as assistants. The Condon Collection contains 60,000 specimens, including invertebrate and vertebrate fossils, paleobotanical remains, and an extensive collection of modern animals that are available to interested researchers for study.

Research Facilities

Students may use a variety of analytical facilities and equipment including a three-component broadband (0.03–50Hz) seismic array, an electron microprobe, a scanning electron microscope with image analysis, x-ray diffraction, FTIR spectroscopy, stable isotope mass spectroscopy, and a geobiology laboratory.

An experimental petrology laboratory covers a range of crustal temperatures and pressures and includes equipment for doing experiments in controlled atmospheres. Two piston-cylinder apparatus with pressure-temperature capability to 35 kilobars and 1,500° C may be used to study crystalline, partially molten, and molten silicates under mantlelike conditions.

Computers are used for much of the research in the department including acquisition and processing of seismic and gravity data and numerical modeling of geophysical processes and geochemical reactions. A geochemistry laboratory is equipped with sophisticated computer programs for thermodynamic calculations of gas-liquid-solid equilibria and reaction processes important in metamorphic, volcanic gas, hydrothermal, and diagenetic systems. The Internet can be accessed through the UONet fiber-optic link. A student computer facility, equipped with PC and Macintosh computers and laser printers, is also connected to the networks.

The sedimentological and paleontological laboratories have, in addition to standard laboratory equipment, an electronic particle-size analyzer, an x-radiography unit, photomicroscopes, a Leitz Aristophot unit, a fully maintained catalog of foraminifera, an acid room, and a conodont-processing laboratory.

Financial Aid for Graduate Students

Most of the department's graduate students are fully supported through teaching and research assistantships. More information about financial assistance and department policies for awarding and renewing teaching and research fellowships may be obtained by reading the *Guide to Graduate Study* on the department website (http://earthsciences.uoregon.edu/graduate-program) or by writing to the department.

Courses

GEOL 101. Exploring Planet Earth. 4 Credits.
Plate tectonics, mantle flow, and magmatism. Volcanoes, earthquakes, mountain building, generation of Earth's crust; rocks and minerals; Earth's internal structure. Comparison with other planets. Laboratory, lecture.

GEOL 102. Exploring Earth's Environment. 4 Credits.
Landforms, surface processes, and interactions between humans and the environment. Weathering, erosion, sedimentation, ground water, streams, glaciers, deserts, oceans, and coastlines; geologic hazards. Laboratory, lecture. Roering.

GEOL 103. Exploring Earth History. 4 Credits.
History of the Earth. Geologic time, sedimentary environments; oceans, mountains, and climate through time; stratigraphic history of North America; evolution of plants and animals. Laboratory, lecture.

GEOL 110. People, Rocks, and Fire. 4 Credits.
Investigation of topics in geology, ecology, and anthropology relevant to contemporary global energy debates; current energy policy issues investigated through term projects.

GEOL 137. Mountains and Glaciers. 4 Credits.
Survey of the geological processes that both create and destroy mountain ranges around the world, and an introduction to geological science.

GEOL 156M. Scientific Revolutions. 4 Credits.
Surveys several major revolutions in our views of the natural and technological world, focusing on scientific concepts and methodological aspects. For nonscience majors. Multilisted with PHYS 156M.

GEOL 198. Laboratory Projects: [Topic]. 1-5 Credits.
Repeatable.

GEOL 199. Special Studies: [Topic]. 1-6 Credits.
Repeatable. Studies of geologic topics combine background lectures with guided field trips to areas of geologic interest.

GEOL 201. Dynamic Planet Earth. 4 Credits.
Processes that cause earthquakes, volcanism, mountain building, and plate tectonics. Includes Earth's origin and internal structure, rocks and minerals, gravity and magnetics. Weekly lectures, two-hour laboratory. Series with GEOL 202, GEOL 203.

GEOL 202. Earth's Surface and Environment. 4 Credits.
Earth materials, the rock record, human interactions with surface environment. Sedimentary rocks and environments, chemical and physical weathering, mineral and energy resources, hydrogeology, ground-water contamination, surface processes, human impacts. Weekly lectures, two-hour laboratory. Series with GEOL 201, GEOL 203.

GEOL 203. History of Life. 4 Credits.
Origin, history, and physical evolution of the Earth; geologic time scales, development of the global stratigraphic section. Weekly lectures, two-hour laboratory. Series with GEOL 201, GEOL 202.

GEOL 213. Geology of National Parks. 4 Credits.
Examines selected geologic features in United States national parks and the processes that form them. Focuses on parks in the western states.

GEOL 304. The Fossil Record. 4 Credits.
Origin of life in Precambrian; evolution of plants and invertebrate animals; evolution of early chordates, fish, amphibians, reptiles, dinosaurs, birds, and mammals; speciation and extinction. Intended for junior and senior nonmajors but also open to geological sciences majors.

GEOL 305. Dinosaurs. 4 Credits.
Overview of the past and present biodiversity of vertebrate animals, including ourselves, dinosaurs, and what ruled the ocean when dinosaurs roamed the land.

GEOL 306. Volcanoes and Earthquakes. 4 Credits.
Mechanisms that cause earthquakes and volcanoes, relation to plate tectonics, associated hazards, examples in Oregon and the western United States.

GEOL 307. Oceanography. 4 Credits.
Characteristics and physical, chemical, and biological processes of the world's oceans. Includes sections on origin of the oceans, plate tectonics, and human use and misuse of oceans.

GEOL 308. Geology of Oregon and the Pacific Northwest. 4 Credits.
The region's geologic and tectonic history and the plate tectonic processes responsible for its evolution.

GEOL 310. Earth Resources and the Environment. 4 Credits.
Geology of energy, mineral, and water resources and environmental issues related to their use. Topics include fossil fuels, metals, nuclear waste disposal, and water pollution.

GEOL 311. Earth Materials. 5 Credits.
Chemical and mineralogical composition of rocks, sediment, and soil. Properties of common minerals; origin of rocks; microscopic study of rock textures; environmental issues.
Prereq: GEOL 101, 102 or 201, 202; coreq CH 221 or 224.

GEOL 315. Earth Physics. 4 Credits.
Physics of basic Earth processes; application of physics to plate tectonics and lithospheric deformation. Topics include forces, deformation, gravity, and seismology. Taught once or more per academic year.
Prereq: MATH 252, PHYS 201.

GEOL 316. Introduction to Hydrogeology. 4 Credits.
Examines the role of water in geologic and environmental processes. Topics include the water cycle, groundwater flow, and contaminant transport.
Pre- or coreq: MATH 252, PHYS 201.

GEOL 318. Introduction to Field Methods. 3 Credits.
Introduction to geologic mapping and related field skills, rock descriptions, cross sections, and structures. Lectures, laboratories, mandatory field trips.
Prereq: GEOL 101–103 or GEOL 201–203.

GEOL 331. Mineralogy. 5 Credits.
Crystal chemistry, systematic study of rock-forming silicate, and selected other minerals, mineral optics, and x-ray diffraction. Lab work with hand samples and petrographic microscopes.
Prereq: GEOL 201, 202 or GEOL 101, 102; coreq: CH 221 or 224.

GEOL 332. Introduction to Petrology. 5 Credits.
Origin and classification of igneous, metamorphic, and sedimentary rocks. Microscopic study of rocks in thin section.
Prereq: GEOL 331.

GEOL 334. Sedimentology and Stratigraphy. 4 Credits.
Sedimentary processes; characteristic properties of sedimentary rocks and their use in interpreting depositional environments; principles of lithostratigraphy and sequence stratigraphy.
Prereq: GEOL 101–103 or GEOL 201–203; pre- or coreq: GEOL 311 or 332.

GEOL 350. Structural Geology. 3 Credits.
Description, analysis, and origin of geologic structures including faults, folds, and tectonites. Focus on kinematic and dynamic analysis of deformation of earth materials.
Prereq: GEOL 318; GEOL 311 or 332.

GEOL 351. Structural Geology Problems. 1 Credit.
Exercises in solving structural geology problems using orthographic and stereographic projection techniques. Problems emphasize calculating stress and strain from structural markers.
Coreq: GEOL 350.

GEOL 352. Structural Geology Laboratory and Field. 1 Credit.
Collection and interpretation of field and map data for structural analysis. Includes field trips, map and cross-section generation, and some computer-based exercises.
Coreq: GEOL 350.

GEOL 353. Geologic Hazards. 4 Credits.
Examines geologic hazards, including both the physical processes that cause them and society's attempt to mitigate them.
Prereq: GEOL 101 or 201.

GEOL 363. MATLAB for Earth Scientists. 2 Credits.
Introduction to MATLAB (Matrix Laboratory) software package, providing data analysis, mathematical modeling, and computer visualization tools and techniques vital to the work of Earth scientists.
Pre- or coreq: MATH 251.

GEOL 399. Special Studies: [Topic]. 1-5 Credits.
Repeatable.

GEOL 401. Research: [Topic]. 1-21 Credits.
Repeatable.

GEOL 403. Thesis. 1-6 Credits.
Repeatable thrice for maximum of 6 credits.
Prereq: earth sciences honors or senior thesis students only.

GEOL 405. Reading and Conference: [Topic]. 1-21 Credits.
Repeatable.

GEOL 406. Field Studies: [Topic]. 1-6 Credits.
Repeatable.

GEOL 407. Seminar: [Topic]. 1-5 Credits.
Repeatable.

GEOL 408. Laboratory Projects: [Topic]. 1-6 Credits.
Repeatable.

GEOL 409. Practicum: [Topic]. 1-6 Credits.
Repeatable.

GEOL 410. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

GEOL 414. Igneous and Metamorphic Petrology. 4 Credits.
Advanced principles of igneous and metamorphic petrogenesis. Gibbs phase rule, phase diagrams, mineral thermodynamics; magma geochemistry and rheology; metamorphic facies, geothermometry and geobarometry. Johnston.
Prereq: GEOL 332; CH 223 or 226H.

GEOL 415. Field Geophysics. 4 Credits.
Introduction to geophysical methods for subsurface investigation, useful for exploration, geotechnical engineering, and characterization of subsurface groundwater and environmental conditions.
Prereq: MATH 112 or PHYS 201.

GEOL 418. Earth and Environmental Data Analysis. 4 Credits.
Tools-based instruction in data analysis for earth and environmental scientists. Topics include descriptive statistics, visualization, uncertainty analysis, hypothesis testing, regression, time series, and directional data.
Prereq: MATH 246 or 251.

GEOL 420. Geocommunication. 3 Credits.
Scientific writing and presentations for the geological sciences. Focus on writing scientific papers and proposals, preparing oral and visual presentations.

GEOL 425. Geology of Ore Deposits. 5 Credits.
Porphyry copper-molybdenum, epithermal, massive sulfides in volcanic rocks, and base and precious metals in sedimentary rocks. Geologic setting, alteration and ore mineral assemblages, and geochemistry of ore formation.
Prereq: CH 223; GEOL 332.

GEOL 431. Paleontology I: Paleozoic Marine Fossils. 4 Credits.
Biostratigraphy, evolution, and paleoecology of life on earth: Paleozoic and some Mesozoic marine invertebrates. Laboratory exercises on fossil specimens.
Prereq: GEOL 103 or 203.

GEOL 433. Paleobotany. 4 Credits.
Evolution and ecology of plants and microbes from the origin of life to global warming. Laboratory exercises and field trip to collect plant fossils.
Pre- or coreq: GEOL 103 or 203.

GEOL 434. Vertebrate Paleontology. 4 Credits.
Evolution of vertebrates, including ourselves, based on fossil evidence. Physical and other evolutionary constraints are addressed, and lab exercises provide practical experience.
Prereq: GEOL 103 or 203.

GEOL 435. Paleopedology. 4 Credits.
Soil formation; mapping and naming fossil soils; features of soils in hand specimens and petrographic thin sections; interpretations of ancient environments from features of fossil soils.
Prereq: GEOL 311 or 332.

GEOL 438. Geobiology. 4 Credits.
Studies how microorganisms interact with geological environments at scales from enzymes to global element cycles.

GEOL 440. Sedimentary Basin Analysis. 4 Credits.
Evolution of sedimentary basins, emphasizing tectonic controls on basin formation and filling. Interpretation of subsidence mechanisms and sedimentary processes through analysis of the stratigraphic record.
Prereq: GEOL 334, GEOL 350.

GEOL 441. Hillslope Geomorphology. 4 Credits.
Hillslope processes and landforms; includes hillslope hydrology, overland flow erosion, weathering and soil formation, soil creep, landslides and related hazards, glacial and periglacial processes, effects of land-use practices and fire, and landscape evolution.

GEOL 451. Hydrogeology. 4 Credits.
Study of the origin, motion, and physical and chemical properties of ground water. Emphasizes quantitative analysis of flow and interaction with geologic materials.
Prereq: CH 222 or CH 225H; GEOL 316.

GEOL 452. Neotectonics and Quaternary Geology. 4 Credits.
Interpretation of active structures from deformed quaternary sediments and surfaces using case histories. Field project uses air photos and field techniques. Repeatable once for maximum of 8 credits.
Prereq: GEOL 334, GEOL 350.

GEOL 453. Tectonics. 3 Credits.
Tectonic processes and examples. Global kinematics of plates and the forces that drive them. Continental deformation in compressional, shear, and extensional settings.
Prereq: GEOL 350 and calculus.

GEOL 454. Fluid Dynamics. 4 Credits.
Introduction to the continuum theory of fluid dynamics, focusing on the Navier-Stokes equations of motion including common simplified limits and extensions. Applications are drawn from Earth and Planetary Science, Biology, and Physics.
Prereq: PHYS 252, MATH 252.

GEOL 455. Mechanical Earth. 4 Credits.
Introduction to continuum mechanics. Includes stress and strain, friction, elasticity, viscous fluids, constitutive laws, equations of motion, and deformation of the Earth.
Prereq: GEOL 315, PHYS 202, or equivalent; MATH 256.

GEOL 462. Environmental Geomechanics. 4 Credits.
Application of fluid and solid mechanics to understanding processes in the earth and environmental sciences. Offered alternate years.
Prereq: GEOL 455.

GEOL 463. Computational Earth Science. 4 Credits.
Practical techniques for scientific computing. Topics include root finding, curve fitting, interpolation, integration and differentiation, optimization, differential equations.
Prereq: MATH 253; GEOL 363 or equivalent.

GEOL 467. Fault Mechanics. 4 Credits.
The physics of faulting throughout the earthquake cycle. Topics include fault friction, seismic rupture, earthquake triggering, and other fault zone processes. Offered alternate years.
Prereq: GEOL 315, MATH 253.

GEOL 468. Introduction to Seismology. 4 Credits.
Introduction to observational, theoretical, and computational seismology. Includes review of earth structure, source representation, ray theory, and seismic wave phenomena.
Prereq: MATH 256, GEOL 455.

GEOL 471. Thermodynamic Geochemistry. 4 Credits.
Introduction to geologic application of classical chemical thermodynamics. Gibbs free energy and its temperature, pressure, and composition derivatives; fugacity, activity, and chemical potential. Solutions, ideal and nonideal.
Prereq: GEOL 311 or 332, CH 223, MATH 253.

GEOL 472. Aqueous-Mineral-Gas Equilibria. 4 Credits.
Aqueous chemistry applied to natural waters (geothermal, diagenetic, continental brines). Equilibrium calculations applied to aqueous-mineral-gas systems.
Prereq: CH 223; MATH 252.

GEOL 473. Isotope Geochemistry. 4 Credits.
Introduction to nuclear physics and isotope systematics; techniques of isotope analysis; applications of stable and radioactive isotopes in geochronology and as tracers of geological processes.

GEOL 503. Thesis. 1-16 Credits.
Repeatable.

GEOL 507. Seminar: [Topic]. 1-5 Credits.
Repeatable.

GEOL 508. Laboratory Projects: [Topic]. 1-6 Credits.
Repeatable.

GEOL 510. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

GEOL 514. Igneous and Metamorphic Petrology. 4 Credits.
Advanced principles of igneous and metamorphic petrogenesis. Gibbs phase rule, phase diagrams, mineral thermodynamics; magma geochemistry and rheology; metamorphic facies, geothermometry and geobarometry. Johnston.

GEOL 515. Field Geophysics. 4 Credits.
Introduction to geophysical methods for subsurface investigation, useful for exploration, geotechnical engineering, and characterization of subsurface groundwater and environmental conditions.

GEOL 518. Earth and Environmental Data Analysis. 4 Credits.
Tools-based instruction in data analysis for earth and environmental scientists. Topics include descriptive statistics, visualization, uncertainty analysis, hypothesis testing, regression, time series, and directional data.
Prereq: MATH 246 or 251.

GEOL 520. Geocommunication. 3 Credits.
Scientific writing and presentations for the geological sciences. Focus on writing scientific papers and proposals, preparing oral and visual presentations.

GEOL 525. Geology of Ore Deposits. 5 Credits.
Porphyry copper-molybdenum, epithermal, massive sulfides in volcanic rocks, and base and precious metals in sedimentary rocks. Geologic setting, alteration and ore mineral assemblages, and geochemistry of ore formation.

GEOL 531. Paleontology I: Paleozoic Marine Fossils. 4 Credits.
Biostratigraphy, evolution, and paleoecology of life on earth: Paleozoic and some Mesozoic marine invertebrates. Laboratory exercises on fossil specimens.

GEOL 533. Paleobotany. 4 Credits.
Evolution and ecology of plants and microbes from the origin of life to global warming. Laboratory exercises and field trip to collect plant fossils.

GEOL 534. Vertebrate Paleontology. 4 Credits.
Evolution of vertebrates, including ourselves, based on fossil evidence. Physical and other evolutionary constraints are addressed, and lab exercises provide practical experience.

GEOL 535. Paleopedology. 4 Credits.
Soil formation; mapping and naming fossil soils; features of soils in hand specimens and petrographic thin sections; interpretations of ancient environments from features of fossil soils.

GEOL 538. Geobiology. 4 Credits.
Studies how microorganisms interact with geological environments at scales from enzymes to global element cycles.

GEOL 540. Sedimentary Basin Analysis. 4 Credits.
Evolution of sedimentary basins, emphasizing tectonic controls on basin formation and filling. Interpretation of subsidence mechanisms and sedimentary processes through analysis of the stratigraphic record.

GEOL 541. Hillslope Geomorphology. 4 Credits.
Hillslope processes and landforms; includes hillslope hydrology, overland flow erosion, weathering and soil formation, soil creep, landslides and related hazards, glacial and periglacial processes, effects of land-use practices and fire, and landscape evolution.

GEOL 551. Hydrogeology. 4 Credits.
Study of the origin, motion, and physical and chemical properties of ground water. Emphasizes quantitative analysis of flow and interaction with geologic materials.

GEOL 552. Neotectonics and Quaternary Geology. 4 Credits.
Interpretation of active structures from deformed quaternary sediments and surfaces using case histories. Field project uses air photos and field techniques. Repeatable once for maximum of 8 credits.

GEOL 553. Tectonics. 3 Credits.
Tectonic processes and examples. Global kinematics of plates and the forces that drive them. Continental deformation in compressional, shear, and extensional settings.

GEOL 554. Fluid Dynamics. 4 Credits.
Introduction to the continuum theory of fluid dynamics, focusing on the Navier-Stokes equations of motion including common simplified limits and extensions. Applications are drawn from Earth and Planetary Science, Biology, and Physics.

GEOL 555. Mechanical Earth. 4 Credits.
Introduction to continuum mechanics. Includes stress and strain, friction, elasticity, viscous fluids, constitutive laws, equations of motion, and deformation of the earth.

GEOL 562. Environmental Geomechanics. 4 Credits.
Application of fluid and solid mechanics to understanding processes in the earth and environmental sciences. Offered alternate years.

GEOL 563. Computational Earth Science. 4 Credits.
Practical techniques for scientific computing. Topics include root finding, curve fitting, interpolation, integration and differentiation, optimization, differential equations.

GEOL 567. Fault Mechanics. 4 Credits.
The physics of faulting throughout the earthquake cycle. Topics include fault friction, seismic rupture, earthquake triggering, and other fault zone processes. Offered alternate years.

GEOL 568. Introduction to Seismology. 4 Credits.
Introduction to observational, theoretical, and computational seismology. Includes review of earth structure, source representation, ray theory, and seismic wave phenomena.

GEOL 571. Thermodynamic Geochemistry. 4 Credits.
Introduction to geologic application of classical chemical thermodynamics. Gibbs free energy and its temperature, pressure, and composition derivatives; fugacity, activity, and chemical potential. Solutions, ideal and nonideal.

GEOL 572. Aqueous-Mineral-Gas Equilibria. 4 Credits.
Aqueous chemistry applied to natural waters (geothermal, diagenetic, continental brines). Equilibrium calculations applied to aqueous-mineral-gas systems.
Prereq: CH 223; MATH 252.

GEOL 573. Isotope Geochemistry. 4 Credits.
Introduction to nuclear physics and isotope systematics; techniques of isotope analysis; applications of stable and radioactive isotopes in geochronology and as tracers of geological processes.

GEOL 601. Research: [Topic]. 1-16 Credits.
Repeatable.

GEOL 602. Supervised College Teaching. 1-16 Credits.
Repeatable.

GEOL 603. Dissertation. 1-16 Credits.
Repeatable.

GEOL 605. Reading and Conference: [Topic]. 1-16 Credits.
Repeatable.

GEOL 606. Field Studies: [Topic]. 1-6 Credits.
Repeatable. Geologic fieldwork principally in connection with graduate thesis or dissertation. Emphasis on individual problems.

GEOL 607. Seminar: [Topic]. 1-5 Credits.
Repeatable.

GEOL 608. Laboratory Projects: [Topic]. 1-3 Credits.
Repeatable.

GEOL 609. Practicum: [Topic]. 1-3 Credits.
Repeatable.

GEOL 610. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

GEOL 620. Advanced Igneous Petrology. 3 Credits.
Ingeous rocks of the ocean basins, continental margins, and stable continental interior including basalts, calcalkaline series, and granites. Content varies according to research interests.
Prereq: GEOL 414/514, 471/571 or equivalent.

GEOL 692. Volcanology. 3 Credits.
Products and processes of volcanism, origin of magmas, eruptive mechanisms, and relation of volcanism to orogeny and tectonic processes.