

ESE BS CONCENTRATION IN GEOLOGICAL SCIENCES

1. PURPOSE AND NATURE OF PROGRAM

Geological science is the study of the Earth and other planets with emphasis on the processes that have shaped them since the origin of the solar system, including the co-evolution of life, oceans, atmosphere, and the Earth's climate system, and the record of that evolution encoded in rocks, soil, ice, and isotopes. The BS in Earth and Space Exploration with a concentration in Geological Sciences (ESE-GS) educates students in the fundamentals of the geological sciences, providing a solid background in chemistry, mathematics and physics, as well as interdisciplinary training in engineering, astronomy and planetary science. Sub-topics include earthquakes, planetary geology, exploration of the ocean and the ocean floor, fossils, groundwater and the fate of environmental pollutants, biogeochemical cycles, mountain building, volcanoes, and petroleum and ore deposits. Students will gain a strong understanding of field methods as well as modern computing, remote sensing and instrumentation, in order to effectively study the natural environment and Earth's resources. Graduates of the program will learn to apply their knowledge for the benefit of the nation, Arizona, and society in general.

2. NEED AND DEMAND FOR THE PROGRAM

The earth and space exploration major addresses critical future shortfalls in the national and regional training of the next generation of geoscientists and aerospace engineers. Arizona has an expanding space industry with major new investments and is prepared to engage new technologies to monitor and understand environmental issues in Arizona, the southwest and throughout the world. Students will have the skills and knowledge to address major issues of global importance, while working in either the private or public sector.

Geological scientists (ESE-GS) in particular will be trained to address the intense pressures that an increasing human population is placing on this planet, gaining skills important to the fields of environmental preservation, resource management and natural hazard assessment. Geological scientists will also be trained to meet the challenges of ongoing and future space exploration, and will be uniquely qualified to study the evolution of other planetary bodies such as the moon and Mars. Furthermore, the ESE concentration in Geological Sciences is required to replace the existing BS in Geological Sciences which is slated to be disestablished in Fall 2010 provided the new concentration is approved. The BS in Geological Sciences currently includes 90 majors, an increase in almost 50% in 2 years. This is a larger number than the current enrollment in the rapidly growing Earth and Space Exploration BS. The new concentration is sufficiently similar to the existing Geological Sciences BS so that no currently enrolled students will be adversely affected. Future students will gain from the integration with the core ESE courses to give an introduction to fundamentals of exploration as a discipline and a stronger background in the evolution of the universe, our galaxy, and our solar system. Many students will be exposed to engineering for exploration design fundamentals in SES 310. In addition, all students will benefit from inclusion in the capstone course of the ESE degree (all in SES 410: Senior Exploration Project I and many in SES 411: Senior Exploration Project II) where geoscience

students will interact with engineering backgrounds in the design of exploration missions (on Earth, in Space, or on other planets).

3. LEARNING OUTCOMES AND ASSESSMENT

- A. **List the knowledge, competencies, and skills** students should have when they graduate from the proposed degree program. (You can find examples of program Learning Outcomes at (<http://www.asu.edu/oue/assessment.html>))

Competencies

- Reduce complex problems to their most important attributes; and design and carry out experiments, models, or observations that address these attributes.
- Capacity for critical thinking regarding scientific and engineering problems and findings
- Ability to work collegially, fairly, and effectively in groups on relevant projects.
- Ability to use technology effectively in learning and research.
- Capacity for informal and formal communication of science concepts through various media (writing, graphics, oral presentations).

Knowledge Outcomes

- Physical and chemical nature of materials that make up the Earth and planets.
- Forces and processes that interact and change the Earth system and planetary bodies through time.
- Processes of formation of igneous, metamorphic, and sedimentary rocks.
- Principles of structural geology and tectonics.
- Interpretation of planetary history from the rock record.
- Supporting concepts of biology, chemistry, geoscience, physics, and mathematics.

Skills Outcomes

- Observe and measure relevant aspects of Earth materials, processes, and structures.
- Ability to construct geologic maps and interpretative geologic cross sections.
- Preparation to progress to professional positions or to graduate studies.

- B. **Describe the plan and methods to assess** whether students have achieved the knowledge, competencies and skills identified in the Learning Outcomes. (You can find examples of assessment methods at (<http://www.asu.edu/oue/assessment.html>))

Student Formative Assessment Metric

- Quality of sample of work completed in milestone course GLG 321 Mineralogy

Student Summative Assessment Metric

- Quality of geologic maps and geologic reports produced in capstone course GLG 452 Field Geology II.

Program Assessment Metrics

- Track career trajectories of graduates for 10 years.
- Annually review quality and effectiveness of capstone course(s) in integrating overall features of the degree program.

4. REQUIREMENTS FOR THE MAJOR (NO CONCENTRATION OPTION)

A. SPECIFIC LIST OF COURSES REQUIRED

The BS degree in Earth and Space Exploration, Concentration in Geological Sciences requires the following core courses: (21 units)

SES 100 Introduction to Exploration (3)

¹SES 101 Earth, Solar System, and Universe I (3)

¹SES 102 Earth, Solar System, and Universe II (3)

¹SES 103 Earth, Solar System, and Universe Laboratory I (1)

¹SES 104 Earth, Solar System, and Universe Laboratory II (1)

¹GLG 101-104 may be substituted for SES 101-104 with advisor approval

²Both GLG 101 and 103 must be taken to secure SQ credit.

³Both GLG 102 and 104 must be taken to secure SG credit.

GLG 310 Structural Geology (3)

GLG 321 Mineralogy (3)

GLG 400 Geology Colloquium (1)

GLG 451 Field Geology I L (3)

In addition, two of the following branch courses must be taken (6 units):

SES 310 Concepts of Elec. and Mech. Engin. Design (3)

GLG 418 Geophysics (3)

GLG 424 Petrology (3)

GLG 435 Sedimentology (3)

GLG 430 Paleontology (3)

GLG 470 Hydrogeology (3) OR CEE 440 Engineering Hydrology (3)

GLG 481 Geochemistry (3)

Two Upper division GLG electives and 6 units of capstone (12 units):

GLG Elective (3)*

GLG Elective (3)*

SES 410 (3)

SES 411 (3) OR GLG 452 Field Geology II L (3)

* Courses must be 300 or 400 level and cannot include GLG 300 or 304

Required courses in other related fields include the following (25 Units):

CHM 113 General Chemistry I SQ (4)

CHM 116 General Chemistry II SQ (4)

MAT 265 Calculus for Engineers I (3) or MAT 270

MAT 266 Calculus for Engineers II (3) or MAT 271

MAT 267 Calculus for Engineers III (3) or MAT 272 or MAT 274 Elementary Differential Equations MA (3) or MAT 275 Modern Differential Equations (3)

PHY 121 University Physics I: Mechanics SQ¹ (3)

PHY 122 University Physics Laboratory I SQ¹ (1)

PHY 131 University Physics II: Electricity and Magnetism SQ² (3)

PHY 132 University Physics Laboratory II SQ² (1)

¹Both PHY 121 and 122 must be taken to secure SQ credit.

²Both PHY 131 and 132 must be taken to secure SQ credit.

TOTAL: 64 units

Changes from existing Geological Sciences BS are as follows. 1. SES 100 is added to introduce exploration as a hybrid science/engineering discipline in the modern era. 2. SES 101-104 replace GLG 101-104 as the introductory core (though GLG 101-104 will still be accepted for articulation and for students transferring into the major). 3. GLG 424 and GLG 435 become branch electives rather than required (many students will still take both). 4. SES 310 is added as a recommended branch course. 5. Geological science students will now participate in the ESE capstone design project (SES 410) though some may substitute the geoscience-focused traditional capstone of geological field camp (GLG 452) for SES 411. 6. MAT 265-267 is the preferred calculus sequence, consistent with the ESE degree, rather than the MAT 270-273 sequence previously required (either sequence is accepted).

B. MAJOR MAP

See Attached for revised BS in ESE concentration in Geological Sciences Major Map
– end of this section.

5. REQUIRED NEW COURSES

None are required for the BS in ESE with concentration in Geological Sciences, all exist in the context of the existing BS in Earth and Space Exploration or the BS in Geological Sciences.

6. PRIMARY FACULTY PARTICIPANTS

Primarily SESE Geoscience faculty: Anbar, Arrowsmith, Burt, Buseckk, Christensen, Clarke, Farmer, Fink, Fouch, Garnero, Greeley, Hartnett, Heimsath, Hervig, Hodges, Knauth, McNamara, Reynolds, Robinson, Semken, Sharp, Shock, Stump, Tyburczy, Vivioni, Wadhwa, Whipple, Williams, Zolotov.

7. MINIMUM RESIDENCY REQUIREMENT

30 units.

Critical Requirements: Students who follow the 20__-20__ catalog year and are entering ASU as either a first-time freshman or transfer from any Arizona public university or Arizona community college must complete critical requirements.

School of Earth and Space Exploration, Tempe Campus
Catalog Year: 20__-20__

Critical Courses in Yellow

Course Subject and Title	Critical Course	Hrs.	Completed ATP: ___ Yes ___ No			Completed AGEC: ___ Yes ___ No	
			Upper Division	Transfer Course/Grade	Minimum Grade if Required	Additional Critical Requirements and/or Notes	
TERM ONE: 0-15 CREDIT HOURS							
CHM 113: General Chemistry I (SQ)	<input checked="" type="checkbox"/>	4	<input type="checkbox"/>			Grade of C or better	
SES 100: Introduction to Exploration	<input checked="" type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better	
SES 101/103: Earth, Solar System, Universe I/Laboratory	<input type="checkbox"/>	4				Grade of C or better	
ENG 101 or 102: First-Year Composition or ENG 105: Advanced First-Year Composition or ENG 107 or 108: English for Foreign Students	<input type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better	
MAT 170 (if necessary) or Social & Behavioral Academic Success Class or First Year Seminar	<input type="checkbox"/>	3	<input type="checkbox"/>				
		1					
TERM TWO: 16-30 CREDIT HOURS							
CHM 116: General Chemistry II (SQ)	<input checked="" type="checkbox"/>	4	<input type="checkbox"/>			Grade of C or better	
MAT 265: Calculus with Analytic Geometry I (MA)	<input checked="" type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better	
SES 103/104: Earth, Solar System, Universe II/Laboratory	<input type="checkbox"/>	4	<input type="checkbox"/>			Grade of C or better	
ENG 101 or 102: First-Year Composition or ENG 105: Advanced First-Year Composition or ENG 107 or 108: English for Foreign Students	<input type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better	
TERM THREE: 31-45 CREDIT HOURS							
GLG 310: Structural Geology	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better	
MAT 266: Calculus with Analytic Geometry II	<input checked="" type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better	
CLS Science and Society	<input type="checkbox"/>	3	<input type="checkbox"/>			Grade of C or better	
Humanities, Fine Arts & Design (HU) and Cultural	<input type="checkbox"/>	3	<input type="checkbox"/>				
Social & Behavioral Sciences (SB) or general	<input type="checkbox"/>	3	<input type="checkbox"/>				
TERM FOUR: 46-60 CREDIT HOURS							
PHY 121/122: University Physics I/Laboratory	<input checked="" type="checkbox"/>	4	<input type="checkbox"/>			Grade of C or better	
GLG 321: Mineralogy		3	<input checked="" type="checkbox"/>			Grade of C or better	
MAT 267: Calculus with Analytic Geometry III OR MAT 275 Modern Differential Equations	<input type="checkbox"/>	3	<input type="checkbox"/>				
General Elective	<input type="checkbox"/>	3					
	<input type="checkbox"/>		<input type="checkbox"/>				
	<input type="checkbox"/>		<input type="checkbox"/>				
	<input type="checkbox"/>		<input type="checkbox"/>				
TERM FIVE: 61-75 CREDIT HOURS							
GLG 400: Colloquium	<input type="checkbox"/>	1	<input checked="" type="checkbox"/>			Grade of C or better	
GLG/SES Branch Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better	
PHY 131/132: University Physics II/Laboratory	<input type="checkbox"/>	4	<input type="checkbox"/>				

Upper Division CLAS Science and Society	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better
General Elective	<input type="checkbox"/>	1	<input type="checkbox"/>			
TERM SIX: 76-90 CREDIT HOURS						
GLG/SES Branch Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better
GLG 451: Field Geology I (L)	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better
Humanities, Fine Arts & Design (HU)	<input type="checkbox"/>	3	<input type="checkbox"/>			
Social & Behavioral Science (SB)	<input type="checkbox"/>	3	<input type="checkbox"/>			
General Elective	<input type="checkbox"/>	3	<input type="checkbox"/>			
	<input type="checkbox"/>		<input type="checkbox"/>			
SUMMER - 3 CREDIT HOURS						
GLG 452: Field Geology II (L)	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better
TERM SEVEN: 91-105 CREDIT HOURS						
SES 410: Senior Design Project I	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better
Upper division SES or GLG Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better
Computer/Statistics/Quantitative applications (CS)	<input type="checkbox"/>	3	<input type="checkbox"/>	<input type="checkbox"/>		
Upper division Humanities, Fine Arts & Design (HU) or Social Behavioral Science (SB)	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			
Upper division General Elective		3				
TERM EIGHT: 106-120 CREDIT HOURS						
Upper division SES or GLG Elective or SES 411	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			Grade of C or better
Upper division General Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			
Upper division General Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			
Upper division General Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			
Upper division General Elective	<input type="checkbox"/>	3	<input checked="" type="checkbox"/>			

Graduation Requirements Summary:

Total Hours (120 minimum)	Total Hrs at ASU (30 hour minimum)	Hrs Resident Credit required for Academic Recognition (56)	Major GPA (2.000 minimum)	Total UD Hrs (45 minimum)	Total Community College Hrs. (64 maximum)
120					

General University Requirements: Legend

- General Studies Core Requirements:
 - Literacy and Critical Inquiry (L)
 - Mathematical Studies (MA)
 - Computer/Statistics/Quantitative applications (CS)
 - Humanities, Fine Arts, and Design (HU)
 - Social and Behavioral Sciences (SB)
 - Natural Science-Quantitative (SQ)
 - Natural Science-General (SG)
- General Studies Awareness Requirements
 - Cultural Diversity in the US (C)
 - Global Awareness (G)
 - Historical Awareness (H)
- First Year Composition

Additional Notes:

- There is room in this map to add a concurrent degree, minor, or certificate