ESE BS CONCENTRATION IN ASTROPHYSICS

1. PURPOSE AND NATURE OF PROGRAM

Within the BS degree in Earth and Space Exploration, the Astrophysics concentration is designed to offer students a fundamental grounding in astronomy and astrophysics, with exposure to the related fields of geology, planetary science and engineering. Students will emerge from this program with the skills to pursue a career in astrophysics, physics, or related fields.
The rigorous classload includes a combination of physics courses taught in SESE and the Department of Physics. Students should emerge from the program with the ability to compete at the national level on standardized Physics exams. The tools of astronomical discovery are increasingly dependent on technological advances, and students will be exposed to engineering principles. Through the Capstone project in the senior year, students will gain valuable experience in translating science drivers into engineering specifics. Students will especially receive training in astronomy and astrophysics, acquiring a strong background in the techniques of galactic and stellar astronomy, extragalactic astronomy and cosmology, and planetary sciences. Students will emerge from the program with the scientific ability to reduce complicated, real-world problems to their essentials and solve them with experimental, observational and theoretical and computational techniques.

Students graduating with an ESE degree with an Astrophysics Concentration will have the broad background necessary to pursue scientific careers in industry, national laboratories, or an advanced research degree. They will also have an awareness of real-world engineering issues pertaining to Earth and Space Exploration.

2. NEED AND DEMAND FOR THE PROGRAM

It is very important to offer the Astrophysics Concentration within the Earth and Space Exploration degree. Interest in astrophysics is high; even without the Concentration being offered, upper division undergraduate astrophysics typically draw about 10 students at a time. We anticipate that a Concentration in astrophysics, we could recruit undergraduates. We conservatively estimate about 25 undergraduate majors per year, with the potential for significant future growth.

Projected Degrees Awarded Annually
Year 1: 0; Year 2: 0, Year 3: 0, Year 4: 20, Year 5: 25

Many undergraduate students taking astrophysics courses plan to pursue astronomy and astrophysics as a career choice. Graduate studies in astronomy or astrophysics are essential for pursuing a career in these fields, either in the context of academia, national laboratories, or industry, including local Arizona high-technology and aerospace employers. Placement into a highly-ranked graduate school will therefore be a concern for astrophysics students graduating from SESE. In this context, it is notable that among

the 30 top-ranked graduate programs in astrophysics (ranked by faculty quality, as measured by perception of scholarly quality of program faculty by faculty at other institutions, compiled by http://graduate-schools.phds.org, 27 have a separate department of astronomy and all 30 offer a separate degree in astronomy or astrophysics. The natural perception for undergraduates interested in pursuing graduate studies in astrophysics is that they should obtain an undergraduate degree in astrophysics. Offering the Astrophysics Concentration will serve this need.

To pursue a graduate education in astrophysics, students will also be required to place well on standardized exams such as the Physics GRE exam. A strong grounding in physics is essential to students in the Astrophysics Concentration, and the curriculum we have developed reflects these considerations. The Astrophysics Concentration within the BS in Earth and Space Exploration will also be unique among graduate programs in its emphasis on the SESE-specific themes of integrating the science with engineering and technology. We anticipate that these unique attributes of the degree will provide Arizona State University with a competitive edge in nationally recruiting high-caliber undergraduate students interested in astrophysics.

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 universe, galaxies, stars, and planets.
• Basic principles and formulas of physics, including mechanics, electricity and magnetism, quantum theory, thermo-dynamics, relativity.
• Basic principles of astrophysics, including hydrodynamics, atomic physics, celestial mechanics, cosmology.
• Principles of experimental and observational techniques.
•Supporting concepts of chemistry, engineering, and mathematics.

Skills Outcomes

- Connect scientific drivers and/or data with engineering applications.
- Construct theoretical models, design and carry out observations, and design and conduct experiments that interrogate a physical system and test astrophysical hypotheses.
- Integrate science and engineering in a capstone project.
- 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 AST 321 Intro to Planetary and Stellar Astrophysics.

Student *Summative* Assessment Metric

- Quality of work and effectiveness of integration of science and technology in the completed Senior Exploration Project (SES 410/411).

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 Astrophysics requires the following core courses:

SES 100 Intro Exploration (3)
[1]SES 101 Earth, Solar System, and Universe I (3)
[1]SES 102 Earth, Solar System, and Universe II (3)
[1]SES 103 Earth, Solar System, and Universe Laboratory I (1)
[1]SES 104 Earth, Solar System, and Universe Laboratory II (1)

AST 321 Intro to Planetary and Stellar Astro. (3)
AST 322 Intro to Galactic and Extragalactic Astro. (3)
AST 421 Astrophysics I (3)
AST 422 Astrophysics II (3)
AST 494 Astrophysics Seminar (1) – one semesters required
PHY 314 Quantum Physics I (3) (pre-req is PHY 241 (previously PHY 252))
GLG 400 Colloquium (1)

SES 410/411 (6)

[1]AST sequence accepted with advisor approval
[2]Both SES 101 and 103 must be taken to secure SQ credit?
[3]Both SES 102 and 104 must be taken to secure SG credit?

In addition, 3 units of upper division electives from SES/AST/GLG/PHY, particularly from the following courses, but others can be substituted with advisor approval:

SES 310 Concepts of Elec. and Mech. Engin. Design (3)
SES 311 Essentials of Astrobiology
GLG 404 Fundamentals of Planetary Sci (3)
SES/AST 498/598 Astno Instr and Data Analysis (3)

Required courses in other related fields include the following:

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)
MAT 275 Modern Differential Equations (3)
PHY 121 University Physics I: Mechanics SQ[1] (3)
PHY 122 University Physics Laboratory I SQ[1] (1)
PHY 131 University Physics II: Electricity and Magnetism SQ[2] (3)
PHY 132 University Physics Laboratory II SQ[2] (1)
PHY 201 Mathematical Methods in Physics (3) **[previously PHY 120]**
PHY 241 University Physics III (3) **[previously PHY 252]**

[1]Both PHY 121 and 122 must be taken to secure SQ credit.
[2]Both PHY 131 and 132 must be taken to secure SQ credit.

Total of 63 credit hours.

B. MAJOR MAP

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

5. REQUIRED NEW COURSES

None are required for the BS in ESE with concentration in Astrophysics.

6. PRIMARY FACULTY PARTICIPANTS

SESE at Introductory Level, faculty for AST courses: Desch, Groppi, Malhotra, Rhoads, Scannapieco, Starrfield, Timmes, Windhorst, and Young.

7. MINIMUM RESIDENCY REQUIREMENT

30 units.

ASU ARIZONA STATE UNIVERSITY

Critical Requirements: Students who follow the 2010-2011 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.

Major Map:ESE, Astrophysics Concentration - Bachelor of Science(B. S.)

School or College, Campus

Catalog Year: 2010-2011

Course Subject and Title	Critical Course	Hrs.	Completed ATP: ___Yes ___ No: Upper Division	Transfer Course/Grade	Minimum Grade if Required	Completed AGEC: ___Yes ___ No: Additional Critical Requirements and/or Notes
TERM ONE: 0-16 CREDIT HOURS						
SES 100 Intro. To Exploration	☐	3	☐		C	
SES 101/103 Earth, Solar System, Universe lecture and lab (SQ)	☐	3	☐		C	
MAT 265 Calculus I (MA)	☑	3	☐		C	
PHY 121/122 University Physics I: Mechanics lecture and lab (SQ)	☑	3	☐		C	
ENG 101 or 102: First-Year Composition or ENG 105: Advanced First-Year Composition or ENG 107 or 108: English for Foreign Students	☐	3	☐		C	
Academic Success Class / First Year Seminar	☐	1	☐			
TERM TWO: 17-30 CREDIT HOURS						
SES 102/104 Earth, Solar System, Universe lecture and lab (SQ)	☐	3	☐		C	
MAT 266 Calculus II	☑	3	☐		C	
PHY 131/132 University Physics II: Electricity and Magnetism, lecture and lab	☑	3	☐		C	
ENG 101 or 102: First-Year Composition or ENG 105: Advanced First-Year Composition or ENG 107 or 108: English for Foreign Students	☐	3	☐		C	
Social & Behavioral Science (SB) and Cultural Diversity (C), Global Awareness (G) or Historical Awareness (H)	☐	3	☐			
TERM THREE: 31-46 CREDIT HOURS						
MAT 267 Calculus III	☑	3	☐		C	
General Elective	☐	3				
PHY 241 University Physics III		3	☐		C	
Humanities, Fine Arts & Design (HU) and Cultural Diversity (C), Global Awareness (G) or Historical Awareness (H)	☐ ☐	3	☐ ☐			
General Elective	☐	3	☐			
TERM FOUR: 47-61 CREDIT HOURS						
MAT 275 Differential Equations	☑	3	☐		C	
PHY 201 Mathematical Methods Physics	☐	3	☐		C	
CLAS Science and Society	☐	3	☐		C	
Social & Behavioral Science (SB) and Cultural Diversity (C), Global Awareness (G) or Historical Awareness (H)	☐	3	☐			
Literacy and Critical Inquiry (L)	☐	3				
TERM FIVE: 62-75 CREDIT HOURS						

PHY 314 Quantum Physics I	☐	3	☑		C	
AST 321 Intro. Planetary Stellar Astrophysics	☐	3	☑		C	
Humanities, Fine Arts & Design (HU)	☐	3	☐			
GLG 400 Colloquium	☐	1	☑		C	
Upper Division General Elective	☐	3	☑			
General Elective	☐	2	☐			
TERM SIX: 76-90 CREDIT HOURS						
SESE Upper Division Elective (e.g., GLG 404)	☐	3	☑		C	
AST 322 Intro. Galactic/Extragalactic Astro.	☐	3	☑		C	
Upper Division CLAS Science and Society	☐	3	☑		C	
Upper Division Literacy and Critical Inquiry (L)	☐	3	☑			
General Elective	☐	3	☐			
TERM SEVEN: 91-105 CREDIT HOURS						
AST 421 Astrophysics I	☐	3	☑		C	
SES 410 Senior Exploration Project I	☐	3	☑		C	
Upper division Humanities, Fine Arts & Design (HU) or Social Behavioral Science (SB)	☐	3	☑			
Upper Division General Elective	☐	3	☑			
Upper Division General Elective	☐	3	☑			
TERM EIGHT: 106-120 CREDIT HOURS						
SES 411 Senior Exploration Project II	☐	3	☑		C	
AST 422 Astrophysics II	☐	3	☑		C	
AST 494 Astrophysics Seminar	☐	1	☑		C	
Upper Division General Elective	☐	3	☑			
Upper Division General Elective	☐	1	☑			
General Elective	☐	3	☐			

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 Cllege 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

------ Forwarded Message
From: Ricardo Alarcon <ricardo.alarcon@asu.edu>
Date: Wed, 21 Oct 2009 10:24:10 -0700
To: Thomas Sharp <tom.sharp@asu.edu>
Subject: Re: Request for impact statements on new BS concentrations and courses

Hi Tom,

Here it is.

All the best,

Ricardo

On 10/20/09 4:38 PM, "Thomas Sharp" <tom.sharp@asu.edu> wrote:

Hi Ricardo

Thank you. These are useful comments.

Tom

On 10/20/09 4:31 PM, "Ricardo Alarcon" <ricardo.alarcon@asu.edu> wrote:

Hi Tom,

I have consulted with Barry Ritchie, chair of undergraduate program committee, and he sent the response below. I also talked to Bob about it and overall we feel that the impact on our program is minimal, i.e., you won't be stealing our students. Anyway, I will see you in a few minutes and we can wrap this up.

Thanks,

Ricardo

------ Forwarded Message
From: Barry Ritchie <Barry.Ritchie@asu.edu>
Date: Tue, 20 Oct 2009 11:59:53 -0700
To: Ricardo Alarcon <RICARDO.ALARCON@asu.edu>
Conversation: Request for impact statements on new BS concentrations and courses
Subject: RE: Request for impact statements on new BS concentrations and courses

Quick review and response:

One serious negative concern/impact: The new concentrations likely will add to the number of students in the engineering physics sequence. In fact, if the program growth is as large as predicted, this would have a sizeable impact on the demand in those classes. For example, can we accommodate an additional 50-100 students in that sequence with the limited lab facilities that we have? Can we be assured of an additional TA line or two to handle the additional sections needed?

A potential positive impact: Offering SES 300 will help alleviate some of the bottleneck

in PHY 333 ***if we can accept the new course as a substitute in our own programs***. Will they restrict SES 300 to majors only or will they allow physics students to take it, too? Unfortunately, the bottleneck is so bad in our program that we could not accept additional students in that class for other majors.

---BGR

Professor Barry G. Ritchie
Department of Physics
Arizona State University
Tempe, AZ 85287-1504

Telephone: (480) 965-4707
Fax: (480) 965-7954

From: Ricardo Alarcon [mailto:ricardo.alarcon@asu.edu]
Sent: Tuesday, October 20, 2009 11:48 AM
To: Barry Ritchie
Subject: FW: Request for impact statements on new BS concentrations and courses
Importance: High

Barry, here it is.

Thanks,

Ricardo

------ Forwarded Message
From: Thomas Sharp <tom.sharp@asu.edu>
Date: Mon, 19 Oct 2009 17:48:52 -0700
To: Ricardo Alarcon <RICARDO.ALARCON@asu.edu>
Conversation: Request for impact statements on new BS concentrations and courses
Subject: FW: Request for impact statements on new BS concentrations and courses

Hi Ricardo

I am the Associate Director for undergraduate studies in SESE. I have emailed Bob Nemanich twice with a request for an impact statement concerning our new concentration in Astrophysics and a new class in Practical Electronics and Instrumentation (SES 330). Unfortunately, I have had no response from Bob. Could you have a look at the attached material and provide a statement for the concentration and (separately) the new course?

Sincerely,

Tom Sharp

Thomas Sharp
Professor and Associate Director for Undergraduate Studies
School of Earth and Space Exploration
Arizona State University
tom.sharp@asu.edu