OHIO STATE GROUP STUDIES REQUEST

College MAPS

Department Astronomy
(e.g., Portuguese)

A. Course Offerings Bulletin Information. Follow instructions in the *OAA Procedures Manual.*

294A Black Holes
Course No. Title of Course

Level U☒ P☐ G☐ Credit Hours: 5

Description (*not to exceed 25 words*): What black holes are, how they form, and how they are discovered

Quarter /Yr: SU ☐ AU ☐ WI ☐ SP ☒ YR 08 Distribution of Class Time: 3 x 1h 18min

Prerequisite(s):

Exclusion or limiting clause:

Repeatable to a maximum of credit hours.

General Information Statement Natural Sciences GEC. Does not count towards astronomy major.

B.General Information *(respond to all items)*:

1 ☐ *This course* has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (list units and attach letters):

N/A.

2. ☐ Attach letters indicating concurrence or objection from academic units that might have jurisdictional Interests.

3. Previous quarter(s) of offering and enrollment: N/A

4. ☐ Attach the course syllabus that includes the topical outline of the course, student learning outcomes and/or course objectives, methods of evaluation, off-campus field experience, and other items as stated in the *OAA Procedures Manual.*

5. Provide the rationale for proposing this group studies topic.

Pilot for new GEC course Astronomy 142.

[over]

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APPROVAL SIGNATURES (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed

[signature] ☒ Approve ☐ Disapprove 2/4/08
ACADEMIC UNIT CHAIR — Date

[signature] ☒ Approve ☐ Disapprove 2/4/08
Academic Unit Undergraduate Studies Committee Chair (Undergrad course) — Date

☐ Approve ☐ Disapprove
Academic Unit Graduate Studies Committee Chair (Undergrad/Graduate course) — Date

☐ Approve ☐ Disapprove
School /College Undergrad Curriculum Committee (Undergrad/Grad course) — Date

☐ Approve ☐ Disapprove
School /College Graduate Curriculum Committee (Undergrad/Grad course) — Date

☐ Approve ☐ Disapprove
School Director (If Appropriate) — Date

☐ Approve ☐ Disapprove
COLLEGE DEAN — Date

☐ Approve ☐ Disapprove
Graduate School (If Appropriate) — Date

☐ Approve ☐ Disapprove
ASC Curriculum Committee Chair (If Appropriate)) — Date

☐ Approve ☐ Disapprove
University Honors Center (If Appropriate) — Date

☐ Approve ☐ Disapprove
Office of International Education (study tour only) — Date

☐ Approve ☐ Disapprove
ACADEMIC AFFAIRS — Date

SCHEDULING INFORMATION

Course No: Limit: Credit Hour Restriction Code Days Time ☐ AM ☐ PM

Section Type: Requested Bldg/Room :

Instructor: S25 Need Type & Characteristics [1-20, max of 5] Qtr ☐ 1st Term ☐ 2nd Term Non-Standard begin/end dates

Revised: 08/98

The Ohio State University
General Education Curriculum (GEC)
Request for Course Approval Summary Sheet

1. **Academic Unit(s) Submitting Request**

   Astronomy

2. **Book 3/Registrar's Listing and Number** (e.g., Arabic 367, English 110, Natural Resources 222)

   Astron 294A

3. **GEC areas(s) for which course is to be considered** (e.g., Category 4. Social Science, Section A. Individuals and Groups; and Category 6. Diversity Experiences, Section B. International Issues, Non-Western or Global Course)

   Category 3, Natural Science, 4. Physical Science Course

4. **Attach:**
   - **A statement as to how this course meets the general principles of the GEC Model Curriculum and the specific goals of the category(ies) for which it is being proposed;**
   - **An assessment plan for the course; and**
   - **The syllabus, which should include the category(ies) that it satisfies and objectives which state how this course meets the goals/objectives of the specific GEC category(ies).**

5. **Proposed Effective Date** Spring 2008

6. **If your unit has faculty members on any of the regional campuses, have they been consulted?** N/A

7. ***Select the appropriate descriptor for this GEC request:***

☐ ***Existing course with no changes to the Course Offerings Bulletin* information.** Required documentation is this GEC summary sheet and the course syllabus.

☐ **Existing course with changes to the *Course Offerings Bulletin* information.** Required documentation is this GEC summary sheet, the course change request, and the course syllabus.

☑ **New course.** Required documentation is this summary sheet, the new course request, and the course syllabus.

All material identical to that for Astronomy 142.

For ASC units, after approval by the academic unit, the documentation should be forwarded to the ASC Curriculum Office for consideration by the appropriate college curriculum committee and the Arts and Sciences Committee on Curriculum and Instruction (CCI). For other units, the course should be approved by the unit, college curriculum committee, and college office, if applicable, before forwarding to the ASC Curriculum Office. E-mail the syllabi and supporting documentation to asccurrofc@osu.edu.

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9. **Approval Signatures**

[signature]	2/4/08
Academic Unit	**Date**
College Office/College Curriculum Committee	**Date**
Colleges of the Arts and Sciences Committee on Curriculum and Instruction	**Date**
Office of Academic Affairs	**Date**

Astronomy 142: Black Holes

GEC Justification

The proposed Astronomy 142 course is being taught as a 5-hour group studies course, Astronomy 294: Black Holes, in Spring 2008. It is proposed as a GEC Natural Sciences course for BA students.

The general learning objectives for GEC courses in the Natural Sciences are:

1. To understand the basic principles and central facts of the physical and biological sciences, and their interrelationships.

2. To understand when, where, and how the most important principles and facts were discovered, thus understanding the key events in the history of science both as events in human history and as case studies in the methods of science.

3. To understand the interaction between science and technology.

4. To understand the social and philosophical implications of major scientific discoveries.

Course Objectives

The specific learning objectives of Astronomy 142 are:

• Qualitative physical understanding of Newton's and Einstein's theories of gravity, space, and time, the similarities and differences between them, and the senses in which Einstein's theory has superseded Newton's.

• Understanding of how Einstein's theory leads to the prediction of black holes and of the properties it predicts black holes to have.

• Understanding of the interplay between gravity, pressure, and nuclear energy generation in governing the life cycle of stars, and of and why the deaths of massive stars are expected to lead to the formation of black holes.

• Understanding of how astronomers discovered the first empirical evidence for black holes and of how they have set out to demonstrate the existence of black holes as conclusively as possible.

• Understanding of why supermassive black holes are thought to be the central engines of quasars, the most luminous objects in the cosmos, and of the observational methods that are used to study quasars and the dormant black holes they have left behind in the centers of galaxies.

• Understanding of the ways that advanced space missions currently under development might lead to deeper understanding of black holes, by measuring X-rays from gas falling towards the event horizon and by measuring gravity waves — propagating ripples in space-time — produced by colliding black holes at the far edge of the universe.

Connection to General Learning Objectives for GEC Natural Science Courses

1. The course will cover perhaps the most fundamental theory of physical science — the theory of gravity — and the applications of gravity and other physical principles to understanding stars, quasars, and black hole formation. In addition, it will emphasize the methodology by which

astronomers use observational data to demonstrate the existence of black holes, a beautiful case study of the interplay between theory and observation in physical science.

2. The course will cover one of the epochal events of the history of physics, the replacement of Newton's theory of gravity by Einstein's, addressing broad issues of theory development and theory change. On a smaller but still fascinating scale, it will describe the controversial origin of black holes as a theoretical idea, the revelation of the energetic universe by the first X-ray satellites, and the discovery of quasars.

3. The course will show how new technologies, especially the ability to observe the universe at previously unobservable wavelengths, have led to breakthroughs in astronomical discovery.

4. Although it is not a primary theme, the course will touch on the ways that Einstein's theory of relativity and the concept of black holes have influenced culture, as metaphors and touchstones in fiction, poetry, film, and even political discourse. The course will also discuss national and international investment in pure science, especially the achievements and costs of the unmanned space program. In pursuing all of these objectives, but especially 2 and 4, the course will be greatly aided by Kip Thorne's outstanding book, which presents the history and personalities behind the discoveries of black holes and gives plenty of attention to the "exotic" aspects of black holes that fire the popular imagination, such as time travel and wormholes.

Astronomy 142: Black Holes

Assessment Plan

The specific course objectives and their relation to the GEC general learning objectives for natural science courses are detailed in the GEC Justification statement. Two main assessment tools will be used in Astronomy 142 to evaluate how well the course is meeting these objectives.

(1) Questions tailored to test the students' grasp of concepts directly linked to the GEC goals for natural science courses will be embedded in the final exam. Students' responses to these particular questions will be scrutinized to see which goals were inadequately met, as evidenced by lower scores on these questions. These areas will receive greater emphasis and class time the next time the course is offered.

(2) An exit survey will be administered to as many students as possible at the conclusion of the course. Students will be given a summary of the specific course objectives and of the GEC Natural Science general learning objectives, and they will be asked whether they strongly agree, agree, disagree, strongly disagree, or neither agree nor disagree with statements such as "This course helped me to understand the basic facts, principles, theories, and methods of modern science," and similar statements related to the other specific and general learning objectives. The exit survey will also solicit narrative evaluations. The exit survey will be used to identify those GEC goals that the students perceive as not being met. These responses will in turn help the instructor modify the content and presentation of the course material to better achieve these goals the next time the course is taught.

Syllabus

Astronomy 142: Black Holes

Instructor: Professor David Weinberg, Dept. of Astronomy
4041 McPherson Lab (4th floor), 292-6543, weinberg.21@osu.edu
Mailbox in 4055 McPherson Lab; phone messages can be left at 292-1773

Course Material

Black holes are among the strangest objects ever conceived by science, with gravity so strong that it traps light and warps space and time almost beyond recognition. But black holes are more than theoretical oddities — astronomical observations provide strong evidence that they exist, in at least two varieties. Stellar mass black holes are created in the explosive deaths of massive stars, and they can "light up" and become detectable by ingesting the outer layers of orbiting companions. Supermassive black holes, millions or even billions of times more massive than the sun, reside at the centers of galaxies and power quasars, the most luminous objects in the universe.

This course will tell the story of black holes: how they were conceived as theoretical ideas, how they might form from dying stars, how they were discovered, what roles they play in cosmic history, how they distort space and time, and some of the remaining mysteries they present to contemporary physics. Along the way we will learn about Newton's theory of gravity, Einstein's theory of space and time, the life cycle of stars, and the nature of quasars. We will also see how astronomers use observations from telescopes and satellites together with basic physical principles to demonstrate the reality of black holes.

Prerequisites

The only prerequisite is math at the level of Math 075 or 076 (actually, well below this level would be sufficient). The math in this course will not go beyond simple algebra, but there will be some equations and geometrical or mathematical reasoning in the lectures and in the assignments.

Textbook

The textbook is *Black Holes and Time Warps: Einstein's Outrageous Legacy*, by Kip Thorne.

This is not your typical science textbook. It was written as a popular book for a broad audience, and it covers both the science of black holes and the history of black hole discoveries. It does not perfectly match to our course material, covering some topics in less detail than we will treat them and other topics in more detail. On the whole, it is a great book, written by one of the world's most creative black hole researchers.

Assignments, exams, and grading:

Grades will be based on three take-home assignments (35% total), two midterm exams (35%), and a final exam (30%). The take-home assignments will consist of short problems for you to work out and should typically take 5-8 hours. In accord with the general policy for introductory level GEC courses in the College of Mathematical and Physical Sciences, the grading scale will approximate a standard C+ curve.

Students with Disabilities

Any student who feels that he or she may need an accommodation based on the impact of a disability should contact me to discuss specific needs. I will work with the Office for Disability Services to verify the need for accommodation and develop appropriate strategies. Students with disabilities who have not previously contacted ODS are encouraged to do so in advance by visiting the ODS website and requesting an appointment.

Academic Misconduct

All OSU instructors are required to report suspected cases of academic misconduct to the Committee on Academic Misconduct. See the University's Code of Student Conduct for details.

Learning objectives

The general learning objectives for GEC courses in the Natural Sciences are:

1. To understand the basic principles and central facts of the physical and biological sciences, and their interrelationships.

2. To understand when, where, and how the most important principles and facts were discovered, thus understanding the key events in the history of science both as events in human history and as case studies in the methods of science.

3. To understand the interaction between science and technology.

4. To understand the social and philosophical implications of major scientific discoveries.

The specific learning objectives of Astronomy 142: Black Holes are:

• Qualitative physical understanding of Newton's and Einstein's theories of gravity, space, and time, the similarities and differences between them, and the senses in which Einstein's theory has superseded Newton's.

• Understanding of how Einstein's theory leads to the prediction of black holes and of the properties it predicts black holes to have.

• Understanding of the interplay between gravity, pressure, and nuclear energy generation in governing the life cycle of stars, and of how and why the deaths of massive stars are expected to lead to the formation of black holes.

• Understanding of how astronomers discovered the first empirical evidence for black holes and of how they have set out to demonstrate the existence of black holes as conclusively as possible.

• Understanding of why supermassive black holes are thought to be the central engines of quasars, the most luminous objects in the cosmos, and of the observational methods that are used to study quasars and the dormant black holes they have left behind in the centers of galaxies.

• Understanding of the ways that advanced space missions currently under development might lead to deeper understanding of black holes, by measuring X-rays from gas falling towards the event horizon and by measuring gravity waves — propagating ripples in spacetime — produced by colliding black holes at the far edge of the universe.

Course Schedule

While the dates of exams and assignments will remain fixed, the schedule of topics is approximate and subject to some adjustment. All readings are from Thorne's book.

Week 1: Overview: Black Holes In Theory and Reality
Reading: Prologue

Week 2: Gravity according to Newton
Friday: Homework 1 handed out.

Week 3: Relativity and spacetime
Reading: Chapter 1. Friday: *Homework 1 due.*

Week 4: Einstein's theory of gravity
Reading: Chapters 2 and 3. Friday: *First midterm exam, in class.*

Week 5: The life and death of stars
Reading: Chapters 4 and 5. Friday: Homework 2 handed out.

Week 6: The discovery of black holes
Reading: Chapters 6 and 8. (Chapter 7 optional.) Friday: *Homework 2 due.*

Week 7: Quasars
Reading: Chapter 9 Wednesday: *Second midterm exam, in class.*

Week 8: Supermassive black holes
Friday: Homework 3 handed out.

Week 9: Rippling spacetime
Reading: Chapter 10 (Chapter 11 optional)
Friday: *Homework 3 due.*

Week 10: Black hole exotica
Reading: Chapters 12 and 14 (Chapter 13 optional)