Term Information

Effective Term	Spring 2023
Previous Value	*Spring 2014*

Course Change Information

What change is being proposed? (If more than one, what changes are being proposed?)

Propose course for new GE Theme: Number, Nature, Mind

What is the rationale for the proposed change(s)?

This course fulfills the theme's goals and ELOs.

What are the programmatic implications of the proposed change(s)?

(e.g. program requirements to be added or removed, changes to be made in available resources, effect on other programs that use the course)?

We anticipate no programmatic changes.

Is approval of the requrest contingent upon the approval of other course or curricular program request? No

Is this a request to withdraw the course? No

General Information

Course Bulletin Listing/Subject Area	Philosophy
Fiscal Unit/Academic Org	Philosophy - D0575
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	2650
Course Title	Introduction to the Philosophy of Science
Transcript Abbreviation	Intr Philos Of Sci
Course Description	A survey of the main philosophical problems relating to the natural sciences.
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week, 12 Week, 8 Week, 7 Week, 6 Week, 4 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus, Lima, Mansfield, Marion, Newark, Wooster
Previous Value	*Columbus, Mansfield, Newark*

Prerequisites and Exclusions

Prerequisites/Corequisites	Prereq: 3 cr hrs in logic or Math above 1075, an ACT Math Subscore of 22 or higher, or Math Placement Level R or better, and 3 cr hrs in natural science, or permission of instructor.
Exclusions	
Previous Value	Not open to students with credit for 255.
Electronically Enforced	No

Cross-Listings

Cross-Listings

Subject/CIP Code

Subject/CIP Code	38.0101
Subsidy Level	Baccalaureate Course
Intended Rank	Freshman, Sophomore, Junior

Requirement/Elective Designation

Number, Nature, Mind
The course is an elective (for this or other units) or is a service course for other units

Previous Value

The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- Students understand how science relates to other forms of enquiry, and how the various sciences relate to each other.
- Students understand whether, and if so, how scientists can make knowledge claims in the absence of observation.

Previous Value

- *Goal NA*

Content Topic List

- Demarcating science
- Scientific theory change
- Social influences on science

Sought Concurrence No

Attachments

- PHILOS 2650_elosNNM.docx: NNM Theme submission form

  (Other Supporting Documentation. Owner: Shuster,Amy Lynne)
- PHILOS 2650_syllabus as of 9.20.2022.docx: Syllabus

  (Syllabus. Owner: Shuster,Amy Lynne)

Comments

- Syllabus updated as per the panel's contingency and recommendation feedback. *(by Shuster,Amy Lynne on 09/20/2022 06:22 PM)*
- Please see Panel feedback e-mail sent 09/20/22. *(by Cody,Emily Kathryn on 09/20/2022 04:17 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Shuster,Amy Lynne	06/06/2022 10:06 AM	Submitted for Approval
Approved	Downing,Lisa J	06/06/2022 10:38 AM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	08/26/2022 10:02 AM	College Approval
Revision Requested	Cody,Emily Kathryn	09/20/2022 04:17 PM	ASCCAO Approval
Submitted	Shuster,Amy Lynne	09/20/2022 06:22 PM	Submitted for Approval
Approved	Lin,Eden	09/21/2022 09:00 AM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	09/21/2022 11:31 AM	College Approval
Pending Approval	Cody,Emily Kathryn Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Hilty,Michael Vankeerbergen,Bernadette Chantal Steele,Rachel Lea	09/21/2022 11:31 AM	ASCCAO Approval

PHILOS 2650: Introduction to the Philosophy of Science

Course Description: Are you interested in science? Many foundational questions about how science works are addressed in philosophy. This course is an introduction to such questions. They include: What is science, and how does it differ from other sorts of enquiry? How can scientists know about what they have not observed? Do the entities posited by our best scientific theories really exist? How are the various sciences — say, physics and chemistry, biology and psychology — related to each other?

Instructor: Prof. Richard Samuels
Email: samuels.58@osu.edu
Tel.: 614-292-1701
Office Address: Room 314H University Hall

Place & Time:

Format of instruction: 3 contact hours per week, seminar format with in-class participation and questions.

Office Hours: Thursday 2:00-3:30 via Zoom. If this time doesn't work for you, please feel free to arrange to meet with me at other times—just ask!

- Online Office hours: https://osu.zoom.us/j/168945559?pwd=cG9NQzRZZjAvSEt1bW9lZG5tbFkrdz09
  - Passcode: OFFICE

GE Theme: Number, Nature, and Mind

Background: Philosophy 2650 focuses on several central philosophical issues regarding science, scientific explanation and scientific methods, including:

Q1: What is science, and how does it differ from other sorts of enquiry?
Q2: How does mathematics that scientists use relate to the natural world?
Q3: How can scientists know about what they have not observed?
Q4: Do the unobservable entities posited by our best scientific theories really exist?
Q5: What makes something a scientific explanation, and why are they valuable?
Q6: Does science show that mathematical entities, such as numbers, really exist?
Q7:Why is mathematics so effective in the natural sciences?

Some of these issues are explicitly concerned with the nature of mathematics and its application to the natural world (Q2, Q6, Q7). However, many the other issues indirectly concern mathematics in one way or another. For example, mathematics is relevant to Q1 because, at least since Gallileo, mathematicization has been viewed as central to the project of science, and mathematics is relevant to Q5 because it is integral to our exemplars of explanation in the mature sciences. This makes Philosophy 2650 an ideal course for the *Number, Nature, and Mind* GE Theme.

Goals and ELOs of Number, Nature, and Mind GE Theme

Goal 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than in the Foundations component.

ELO 1.1 Engage in critical and logical thinking about the topic or idea of the Number, Nature and Mind theme.

As described in this syllabus and background statement, students will engage in critical and logical thinking about the nature of mathematics, and its application to the natural world. Though such engagement will occur throughout the semester, it is perhaps most pronounced in the following modules:

- *How does mathematics relate to the natural world? (Sessions 10-14)* The purpose of this module will be to introduce students to issues about the nature of mathematical truth. For example, are the very abstract empirical truths, as J.S. Mill claimed, or are they analytic truths (roughly definitional truths) as the logical positivists claimed?
- *Indispensability Arguments: Does science show that mathematical entities, such as numbers, really exist? (Sessions 20-22)* The purpose of this module will be to introduce students to a very influential line of argument, due to Quine and Putnam, which purports to show that the indispensability of mathematics to natural science provides us with grounds to believe that abstract mathematical objects, such as numbers, exist.
- The Application of Mathematics to the Natural World: Why is it so effective? (Sessions 26-27) The purpose of this aspect of the course is to introduce students to Eugene Wigner's famous puzzle regarding the effectiveness of mathematics in the natural sciences, and to consider some (partial) answers to Wigner's puzzle.

Such topics will be the focus of the readings and reading response questions for sessions 10-14, 20-22 and 26-27, will be central to our in-class discussions, and will form the focus of the second essay assignment. In addition, questions relating to these issues will figure prominently in the midterm and final test.

ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the topic or idea of the Number, Nature and Mind theme.

Though such engagement is pervasive throughout the course, this ELO is perhaps most clearly addressed by the following course modules:

- How does mathematics relate to the natural world? (Sessions 10-14)
- Indispensability Arguments: Does science show that mathematical entities, such as numbers, really exist? (Sessions 20-22)
- The Application of Mathematics to the Natural World: Why is it so effective? (Sessions 26-27)

Each of these modules is concerned with fundamental philosophical issues about the nature and/or application of mathematics. Each module will involve reading assignments, reading response questions, and in-class discussions that require advanced, in-depth, scholarly exploration of the relevant issues.

Goal 2: Successful students will integrate approaches to the Number, Nature, and Mind theme by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in the future.

ELO 2.1 Identify, describe, and synthesize approaches to or experiences as they apply to the theme of Number, Nature and Mind.

Throughout the course students are challenged to identify, describe and sythesize different views about the role of mathematics and mathematical reasoning to the empirical sciences. For example:

- We identify, describe and compare competing accounts of the relationship between mathematics and the natural world (Sessions 10-14)
- We identify, describe and synthesize different views about the extent to which mathemtics is indispensable to the empirical sciences (Sessions 20-22)
- We identify, describe and synthesize different approaches to understanding the role of mathemtics in scientific discovery (Sessions 26-27)

ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.

Philosophy 2650 seeks to address this ELO in a variety of ways:

- At a concrete level, the development and progression of students in Philosophy 2650 is traced most clearly through both the increasing sophistication of the assignments that they

complete. For example, the topic of the first essay is a relatively circumscribed one – an assessment of Karl Popper's well-known account of science. In contrast, the final test will require students to address questions that integrate material from distinct modules –e.g. to compare abductive inference for unobservable entities, such as quarks, and analogous inferences to the existence of mathematical entities, such as numbers.

- At a more abstract level, student reflection and self-assessment occurs through in-class discussion, and reading response questions. For example, throughout the course students will routinely be asked questions of the form 'What do you think is most important?' and 'Which theory do you find most plausible and why?' Among other things, such questions are designed to prompt student reflection and to initiate conversations that involve critical self-evaluation of their initial views.

Class discussions and reading response questions will also encourage students to reflect on their prior experience of taking science classes, and to apply newly acquired arguments and ideas to these experiences. (For example, in discussing the so-called 'No Miracles' students will be required to explain how the argument applies to Mendel's explanation of the data from his hybridization experiments.)

Goal 3: Successful students will experience and examine mathematics as an abstract formal system accessible to mental manipulation and/or mathematics as a tool for describing and understanding the natural world.

ELO 3.1 Analyze and describe how mathematics functions as an idealized system that enables logical proof and/or as a tool for describing and understanding the natural world.

This course will analyze and describe how mathematics functions as tools for describing and understanding the natural world. For example:

- Sessions 10-14 are central concerned with the relationship between mathematics and the nature world – whether, for example, 'pure' mathematical propositions are highly abstract descirptions of the natural world, or descriptions of a non-empirical realm of abstracta.
- Sessions 20-22: Are centrally concerned with whether mathematics is indispensable to our scientific theories.
- Sessions 23 & 25 are centrally concerned with the role of mathematics in scientific explanations.
- Sessions 26 & 27 are centrally concerned with the role of mathematics in scientific inference and scientific discovery.

Students experience the above sorts of ideas through class discussions, readings, reading-response questions, take-home tests and essay assignments.

Readings: All readings will be available online via the Carmen course homepage. It is, of course, mandatory to read the assigned readings.

Grading Scheme:
93–100: A
90–92.9: A-
87–89.9: B+
83–86.9: B
80–82.9: B-
77–79.9: C+
73–76.9: C
70 –72.9: C-
67 –69.9:
D+ 60 –66.9:
D Below 60: E

Course Requirements & Grading: Your overall course grade will be assigned on the basis of the following components (percentage of overall grade in parenthesis):

- *Papers:* You will be required to write two short papers, each approximately 1000 words in length. Further information regarding topics, guidelines and due date for the papers will be distributed later in the course. (The papers will be worth 20% each.)
- *Tests:* (a) There will be a mid-term test in class (20%) and (b) a cumulative end-of-term test (20%). Further information will be provided closer to the test dates
- *Attendance & Participation:* You are expected to attend and to participate in class (10%).
- *Reading Responses:* You will be assigned an online reading response question each week. Your response should be uploaded to Carmen by the specified deadline – typically a Monday at 5pm. (10%)

Please note:
a) Extensions will only be given under the most extraordinary of circumstances.
b) Further information regarding each of the above assignment – topics, due date, guidelines etc. – will be distributed at the relevant times later in the semester.

Disabilities: The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Academic misconduct: It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct **http://studentlife.osu.edu/csc/**.

Class Conduct: Consistent, respectful, and informed participation is expected from every student in the course. This includes:

- Respectful discussion that avoids personal history
- No email or internet usage during class
- Cell phones turned off when class begins.

Topics & Readings

Notes: i) The list of topics and readings is tentative. Expect some changes. ii) All readings will be made available via Carmen. iii) Unless indicated otherwise, the readings are mandatory.

Introduction

Session 1: Introduction & Course Mechanics

Session 2: The Philosophy of Science (Introduced)

- Peter Godfrey-Smith *Theory and Reality*, Ch.1

The Demarcation Problem: What *is* science?

Session 3: Logical positivism

- Sven Ove Hansson. "Science and Pseudoscience", *Stanford Encyclopedia of Philosophy* (esp. Sec. 1-3)
- A.J. Ayer "Logical Positivism"
- Peter Godfrey-Smith *Theory and Reality*, Ch.2 (esp. 2.1-2.3)

Session 4: Challenges to logical positivism

- Peter Godfrey-Smith *Theory and Reality*, Ch.2 (esp. 2.4)
- Pierre Duhem "Physical Theory and Experiment"

Session 5: Falsificationism

- Karl Popper "Science: Conjectures and Refutations"

Session 6: Lakatos on Demarcation and Falsificationism

- Imre Lakatos "Science and Pseudoscience"
    - **Distribute 1st essay assignment**

The Problem of Induction: How can scientists know about what they have not observed?

Session 7: The problem of induction introduced

- David Hume *Enquiry Concerning Human Understanding* Sections 4 & 5
- Peter Lipton "Induction"

Session 8: Popper's "solution" to the problem of induction

- Karl Popper, *The Problem of Induction*
- Wesley C. Salmon, *Rational Prediction*

Session 9: Inference to the Best Explanation

- Gilbert Harman "The Inference to the Best Explanation"

How does mathematics relate to the natural world?

Session 10: Mathematical truths are empirical truths

- Mill, *Logic*, Book II, Ch. VI (252-262) [on arithmetic] [1843]

Session 11: Mathematical Truths are not Empirical Truths

- Frege, *Foundations of Arithmetic*, sections 9-17 (12-24) [1884]

Session 12: Mathematical Truths are Analytic Truths

- Hempel, On the nature of mathematical truth. (377-393) [1945]

Session 13 & 14: How can we know mathematical truths?

- Benacerraf, Mathematical truth. (403-420) [1973]

Midterm

Session 15: MIDTERM REVIEW

Session 16: MIDTERM

Scientific Realism: Do the entities posited by our best scientific theories really exist?

Session 17: Realism & Its Alternatives
- Maxwell, Grover (1962) "On the Ontological Status of Theoretical Entities"

Session 18: The "no miracles" argument
- Musgrave, Alan (1988) 'The Ultimate Argument for Scientific Realism'

Session 19: The pessimistic meta-induction
- Laudan, Larry (1981) "A Confutation of Convergent Realism", *Philosophy of Science*, 48: 19–48.
    - **Distribute 2nd essay assignment**

Indispensability: Does science show that mathematical entities, such as numbers, really exist?

Session 20: Science shows that mathematical entities exist
- Quine, Things and Their Place in Theories, 1-23 [1981]

Session 21: Science does not show that mathematical entities exist
- Field, *Science Without Numbers*, ch. 1: Why the Utility of Mathematical Entities is Unlike the Utility of Theoretical Entities, 7-16. [1980/2015]

Session 22: Maybe science cannot do without mathematical entities after all?
- Colyvan, There is No Easy Road to Nominalism, 285-306 [2010]

Scientific Explanation: What makes something a scientific explanation, and why are they valuable?

Session 23: The Deductive-Nomological Model
- Carl G. Hempel "*Two Basic Types of Scientific Explanation*"

Session 24: The Causal-Mechanical Model
- Jim Woodward "Explanation" in *The Blackwell Guide to the Philosophy of Science*.

Session 25: Unificationist Models of Explanation
- Jim Woodward "Explanation" in *The Blackwell Guide to the Philosophy of Science*.

The Application of Mathematics to the Natural World: Why is it so effective?

Session 26: The effectiveness of mathematics is mysterious
- Wigner, The Unreasonable Effectiveness of Mathematics in the Natural Sciences, reprinted in *Symmetries and Reflections*, 222-237. [1967]

Session 27: The effectiveness of mathematics is not mysterious
- Bangu, *The Applicability of Mathematics in Science: Indispensability and Ontology*, ch. 6: Mathematics and Scientific Discovery, 110-132.

Session 28: END-OF-TERM *REVIEW*

New Theme Course Submission Form

2650 Introduction to the Philosophy of Science

Submitted for approval for the new theme Number, Nature, and Mind

Background Statement

As described in detail on the syllabus, Philosophy 2650 focuses on several central philosophical issues regarding science, scientific explanation and scientific methods, including:

Q1: What is science, and how does it differ from other sorts of enquiry?
Q2: How does mathematics that scientists use relate to the natural world?
Q3: How can scientists know about what they have not observed?
Q4: Do the unobservable entities posited by our best scientific theories really exist?
Q5: What makes something a scientific explanation, and why are they valuable?
Q6: Does science show that mathematical entities, such as numbers, really exist?
Q 7:Why is mathematics so effective in the natural sciences?

Some of these issues are explicitly concerned with the nature of mathematics and its application to the natural world (Q2, Q6, Q7). However, many the other issues indirectly concern mathematics in one way or another. For example, mathematics is relevant to Q1 because, at least since Gallileo, mathematicization has been viewed as central to the project of science, and mathematics is relevant to Q5 becuase it is integral to our exemplars of explanation in the mature sciences. This makes Philosophy 2650 an ideal course for the *Number, Nature, and Mind* GE Theme.

The 3-credit hour course is comprised of two weekly seminars (80 minutes each) in which we will discuss a selection of readings from influential philosophers, and scientists. Mastery of the material will be assessed on the basis of two papers (each 1000 words), two take-home tests, class attendance andf participation, and weekly reading response questions. These various assignments and activities will play a central role in achieving the ELOs and assessing that achievement.

Overview

Each category of the General Education (GE) has specific learning goals and Expected Learning outcomes that connect to the big picture goals of the program. Expected Learning Outcomes (ELOs) describe the knowledge or skills students should have by the end of the course. Courses in the GE Themes must meet the ELOs common for **all** GE Themes and those specific to the Theme, in addition to any ELOs the instructor has developed specific to that course.

The prompts below provide the goals of the GE Themes and seek information about which activities (discussions, readings, lectures, assignments) provide opportunities for students to achieve the ELO's associated with that goal. The answer should be concise and use language accessible to colleagues outside of the submitting department or discipline. The specifics of the activities matter—listing "readings" without a reference to the topic of those readings will not allow the reviewers to understand how the ELO will be met. However, the panel evaluating the fit of the course to the Theme will review this form in conjunction with the syllabus, so if readings, lecture/discussion topics, or other specifics are provided on the syllabus, it is not necessary to reiterate them within this form.

Goals and ELOs shared by *all* Themes

Goal 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than the foundations. In this context, "advanced" refers to courses that are e.g., synthetic, rely on research or cutting-edge findings, or deeply engage with the subject matter, among other possibilities.

Goal 2: Successful students will integrate approaches to the theme by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

For each of the ELOs below, please identify and explain course assignments, readings, or other activities within this course that provide opportunity for students to attain the ELO. If the specific information is listed on the syllabus, it is appropriate to point to that document. The ELOs are expected to vary in their "coverage" in terms of number of activities or emphasis within the course. Examples from successful courses are shared on the next page.

ELO 1.1 Engage in critical and logical thinking.	Students will engage in critical and logical thinking regarding various aspects of the philosophy of science though a variety of means: • Each of the the main written assignments – the two essays, and two take-home tests – require critical engagement with influential philosophical theories and arguments, and require that student develop sustained logical analyses of these theories and arguments. • In-class discussions are centrally concerned with critically assessing a range of influential theories and arguments via the application of sustianed logical thinking. • Reading response questions will require students to provide critical evaluations of the readings.
ELO 2.1 Identify, describe, and synthesize approaches or experiences.	Many of the topics discussed in Philosophy 2650 are inherently synthetic in that they require systematic reflection on – and the integration of – distinct ideas and methods from multiple disciplines, including the history of ideas, the philosophy of science, the natural sciences, and mathematics. The development of philosophy of science involved an interplay between diverse approaches and themes in philosophy, mathematics, as well as the empirical sciences. Throughout the course students are challenged to identify and describe these approaches, characterize the interplay between them, and to assess how, if at all, the synthesis of these strands of thought have led to plausible answers to central questions about the nature of scientific enquiry.

	Students will experience these challenges in class discussions, in their course reading, when addressing reading response questions, and when doing their written assignments.
ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.	Philosophy 2650 seeks to addess this ELO in a variety of ways: • At a concrete level, the development and progression of students in Philosophy 2650 is traced most clearly through both the increasing sophistication of the assignments that they complete. For example, the topic of the first essay is a relatively circumscribed one – an assessment of Karl Popper's well-known account of science. In constrast, the final test will require students to address questions that integrate material from distinct modules –e.g. to compare abductive inference for unobservable entitites, such as quarks, and analogous inferences to the existence of mathematiucal entitites, such as numbers. • At a more abstract level, student reflection and self-assessment occurs through in-class discussion, and reading response questions. For example, throughout the course students will routinely be asked questions of the form 'What do you think is most important?' and 'Which theory do you find most plausible and why?' Among other things, such questions are designed to prompt student reflection and to inititate conversations that involve critical self-evaluation of their initial views. • Class discusions and reading response questions will also encourage students to reflect on their prior experience of taking science classes, and to apply newely acquired arguments and ideas to these experiences. (For example, in discussing the so-called 'No Miracles' students will be required to explain how the argument applies to Mendel's explanation of the results from his hybridization experiments.)

Goals and ELOs of the GE Theme: Number, Nature, and Mind

GOAL 1: 1. Successful students will analyze the nature of mathematics and/or mathematical reasoning at a more advanced and in-depth level than in the Foundations component.
GOAL 2: Successful students will integrate approaches to number, nature, and mind by making connections to their own experience of mathematical thinking and its application in the world, and by making connections to work they have done in previous classes and/or anticipate doing in the future.
GOAL 3: Successful students will experience and examine mathematics as an abstract formal system accessible to mental manipulation and/or mathematics as a tool for describing and understanding the natural world or human cognition.

Course subject & number

Enter your ELOs in the Table below, editing and removing rows as needed. There should be at least one ELO for each goal, and they should be numbered to correspond to the goal (e.g., ELO1.1 is the first ELO for Goal 1, ELO 2.2 would be the second ELO for the second goal).

For each ELOs, please identify and explain course assignments, readings, or other activities within this course that provide opportunity for students to attain the ELO. If the specific information is listed on the syllabus, it is appropriate to point to that document. The number of activities or emphasis within the course are expected to vary among ELOs. Examples from successful courses are shared below.

ELO 1.1 Engage in critical and logical thinking about the nature and/or application of mathematical reasoning.	As described in the syllabus and background statement, students will engage in critical and logical thinking about the nature of mathematics , and its application to the natural world. Though such engagement will occur throughout the semester, it is perhaps most pronounced in the following modules: • *How does mathematics relate to the natural world? (Sessions 10-14)* The purpose of this module will be to introduce students to issues aobut the nature of mathematical truth. For example, are the very abstract empirical truths, as J.S. Mill claimed, or are they analytic truths (roughly definitional truths) as the logical positivists claimed? • *Indispensability Arguments: Does science show that mathematical entities, such as numbers, really exist? (Sessions 20-22)* The purpose of this module will be to introduce students to a very influential line of argument, due to Quine and Putnam, which purports to show that the indispensability of mathematics to natural science provides us with grounds to believe that abstract mathematical objects, such as numbers, exist. • *The Application of Mathematics to the Natural World: Why is it so effective? (Sessions 26-27)* The purpose of this aspect of the course is to introduce students to Eugene Wigner's famous puzzle regarding the effectiveness of mathematics in the natural sciences, and to consider some (partial) answers to Wigner's puzzle. Such topics will be the focus of the readings and reading response questions for sessions 10-14, 20-22 and 26-27, will be central to our in-class discussions, and will form the focus of the second essay assignment. In addition, questions relating to these issues will figure promintently in the midterm and final test.

ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the philosophical and/or cognitive foundations of mathematics and/or the application of mathematics in understanding the natural world or human cognition.	Though such engagement is pervassive throughout the course, this ELO is perhaps most clearly addressed by the following course modules: • *How does mathematics relate to the natural world? (Sessions 10-14)* • *Indispensability Arguments: Does science show that mathematical entities, such as numbers, really exist? (Sessions 20-22)* • *The Application of Mathematics to the Natural World: Why is it so effective? (Sessions 26-27)* Each of these modules is concerned with findamental philospihcal issues about the nature and/or application of mathematics. Each module will involve reading assignments, reading response questions, and in-class discussions that require advanced, in-depth, scholarly exploration of the relevant issues.
ELO 2.1 Identify, describe, and synthesize approaches to or experiences of the role of mathematics and mathematical reasoning in different academic and non-academic contexts.	Throughout the course students are challenged to identify, describe and sythesize different views about the role of mathematics and mathematical reasoning to the empirical sciences. For example: • We identify, describe and compare competing accounts of the relationship between mathematics and the natural world (Sessions 10-14) • We identify, describe and synthesize different views about the extent to which mathemtics is indispensable to the empirical sciences (Sessions 20-22) • We identify, describe and synthesize different approaches to understanding the role of mathemtics in scientific discovery (Sessions 26-27)
ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.	Philosophy 2650 seeks to addess this ELO in a variety of ways: • At a concrete level, the development and progression of students in Philosophy 2650 is traced most clearly through both the increasing sophistication of the assignments that they complete. For example, the topic of the first essay is a relatively circumscribed one – an assessment of Karl Popper's well-known account of science. In constrast, the final test will require students to address questions that integrate material from distinct modules –e.g. to compare abductive inference for unobservable entitites, such as quarks, and analogous inferences to the existence of mathematiucal entitites, such as numbers.

	• At a more abstract level, student reflection and self-assessment occurs through in-class discussion, and reading response questions. For example, throughout the course students will routinely be asked questions of the form 'What do you think is most important?' and 'Which theory do you find most plausible and why?' Among other things, such questions are designed to prompt student reflection and to inititate conversations that involve critical self-evaluation of their initial views. • Class discusions and reading response questions will also encourage students to reflect on their prior experience of taking science classes, and to apply newely acquired arguments and ideas to these experiences. (For example, in discussing the so-called 'No Miracles' students will be required to explain how the argument applies to Mendel's explanation of the data from his hybridization experiments.)
ELO 3.1 Analyze and describe how mathematics functions as an idealized system that enables logical proof and/or as a tool for describing and understanding the natural world or human cognition.	This course will analyze and describe how mathematics functions as tools for describing and understanding the natural world. For example: • Sessions 10-14 are central concerned with the relationship between mathematics and the nature world – whether, for example, 'pure' mathematical propositions are highly abstract descirptions of the natural world, or descriptions of a non-empirical realm of abstracta. • Sessions 20-22: Are centrally concerned with whether mathematics is indispensable to our scientific theories. • Sessions 23 & 25 are centrally concerned with the role of mathematics in scientific explanations. • Sessions 26 & 27 are concentrally concerned with the role of mathematics in scientific inference and scientific discovery. Students experience the above sorts of ideas through class discussions, readings, reading-response questions, take-home tests and essay assignments.