REQUIRED READING:


COURSE OBJECTIVES AND SCOPE

There is a widespread belief among scientists and engineers that science and religion are essentially unrelated areas of human inquiry. According to this outlook (which is sometimes referred to as the ‘doctrine of non-overlapping magisteria’), science ought to limit itself to factual questions about nature, and religion should deal with issues related to meaning and value. As long as this distinction is observed, there is no apparent reason why the two disciplines should not coexist peacefully.

Although the proposed approach provides a sensible compromise, there seems to be something rather artificial in such a strict separation. Indeed, since religion represents a global view of the world, it must necessarily make claims that concern nature and our place in it. As such, it is bound to conflict with science on a variety of issues (miracles, evolution and the creation of the universe come to mind immediately). If we are, therefore, inclined to be realistic (as scientists and engineers ought to be), we should assume that there is a significant overlap between theology and science, and consider the consequences.

The main purpose of this course is to examine a number of key theological claims, and evaluate whether they have a rational justification from a scientific perspective. In thinking about what the term “rational” means in this context, it is useful to recognize that our actions and opinions are guided by what physicist (and historian of science) Gerald Holton describes as a “robust, map-like constellation of … beliefs about how the
world as a whole operates." He refers to this overall outlook that shapes our attitudes as a Weltbild (which is a somewhat broader German word for “world view”).

Although the Weltbild of any given individual depends to a large extent on his social, ethnic and educational background, it is fair to say that it always contains a subset of beliefs that pertain to the natural world. It is perhaps here that we might locate an appropriate meaning for the attribute “rational,” at least when it comes to scientifically minded individuals. It is reasonable to assume that for such a person, a coherent world view would be one that satisfies the following two conditions:

1) The set of “core” beliefs about the natural world must be compatible with existing scientific knowledge.

2) The “non-scientific” core beliefs should be consistent (at least in some measure) with the scientific ones.

In applying these criteria, it is important to keep in mind that the term “consistent” must be used somewhat loosely. Indeed, I seriously doubt that the entire mindset of any individual could pass a strict test of logical soundness (which is perhaps what makes us human in the first place). With that in mind, one could argue that the rationality of our Weltbild can be justified by establishing appropriate “logical bridges” between the disparate clusters of views that constitute it. Formal proofs are of little use in this enterprise, and should ultimately give way to analogies and metaphors.

What is it about analogies and metaphors that makes them so suitable for this purpose? The primary motive for focusing on these two modes of description stems from the fact that they have always been a natural tool for explaining difficult concepts, both in science and in theology. If these two disciplines are seen as manifestations of the same overarching reality (as Christian theology suggests), then it is perfectly reasonable to assume that analogies can also help bridge the apparent gap that separates them. From a theological perspective, what we are really proposing here amounts to adding a certain number of “scientific” metaphors to the already existing traditional ones. The potential value of such metaphors has been recognized by several contemporary thinkers:

“Metaphors ‘fund’ theology, providing the language and images out of which theological concepts grow; they describe the unknown in terms of the known. … When metaphors lose their original meaning and fruitfulness, the theology built upon them must be reconstructed, drawing upon new metaphors appropriate for a new age… It seems reasonable that physics, as well as biology and the other sciences which infuse our culture, can be a source of religious metaphors.” Robert J. Russell

In order to draw the appropriate analogies, it will be necessary to consider a number of scientific theories in some detail. The primary focus will be on chaos theory, with metamathematics, quantum mechanics, relativity and string theory as supplemental topics. Since each one of these areas entails very advanced mathematical skills, the course clearly meets (and probably exceeds) the standard requirements for a technical elective in engineering. Unlike other electives, however, in this case the technical
knowledge is not an end in its own right. It is rather a means for a better understanding of the theological and philosophical issues that will be raised.

The course is structured in a way that allows us to treat scientific and theological topics in parallel. What this means is that every technical issue will be accompanied by a theological question that is in some way related to it. This dialogue should provide an opportunity to compare scientific and religious perspectives, and to explore ways of reconciling possible differences.

What should engineering students hope to gain from a course like this? At a minimum, they will acquire insights into some of the most perplexing phenomena of modern science. The fact that the subtle workings of nature are often thoroughly counterintuitive ought to excite some curiosity and a sense of wonder. It is true, of course, that not all of us share this kind of enthusiasm. Those who are indifferent to such matters are probably better off taking a more marketable technical elective, with less math and more applications. It is important to make this clear since some of the material is difficult, and cannot be mastered without proper motivation. Those who persevere, however, will develop a set of sophisticated analytical tools that will enable them to think independently about these issues, and possibly harmonize their religious beliefs with their profession on a deeper level. It is my hope that those who take the course will continue this line of inquiry long after their formal education is completed.

**LEARNING OUTCOMES**

Students who successfully complete this course should be able to:

1. Solve systems of nonlinear algebraic equations using numerical techniques.
2. Analyze the stability properties of linear and nonlinear dynamic systems.
3. Distinguish between different types of attractors (including those that characterize chaotic behavior).
4. Identify different types of bifurcations in dynamic systems with varying parameters.
5. Grasp the philosophical and theological implications of chaos theory, in the context of phenomena such as intermittency and hypersensitivity to initial conditions.
6. Understand the interplay between chance and lawful behavior in complex systems, particularly as it pertains to the emergence of novel forms of organization in nature.
7. Understand the epistemological limitations of scientific explanations, and relate this knowledge to the theological method of inquiry.
8. Analyze and compare different philosophical and theological positions in the existing literature on science and religion (using at least three sources).
9. Reflect on their own views about religion and relate them to their scientific training.
Outcomes 1 – 4 will be evaluated through homework assignments, a midterm exam and a project (in Matlab). Items 5 – 9 will be assessed through weekly class discussions, the online discussion forum and through the final essay.

**GRADING**

- Project 15%
- Homework 20%
- Midterm Exam 25%
- Final Essay 25%
- Class Participation 15%

**PROJECT.** One project will be assigned, with an emphasis on the analysis and simulation of chaotic systems using Matlab. You will be expected to do a fair amount of programming (in the context of Matlab m-files). Students can work in pairs (a single report is required for each group).

**HOMEWORK.** There will be three homework assignments, which are actually “mini-projects.” Each of these assignments will require both theoretical work and Matlab simulation. Students can work in pairs (a single report is required for each group).

**MIDTERM EXAM.** The Midterm exam will focus on the material covered in the first six weeks of class. It will include topics such as the analysis of linear and nonlinear dynamic systems, stability and bifurcations.

**ESSAY.** In the final essay, you will be asked to provide your own views regarding the relationship between science and religion. You are expected to select one of the ten theological questions discussed in class and expand on it. You may combine several questions or perhaps propose some of your own; however, all such modifications will be subject to approval by the instructor. The essay should include the theoretical background for your discussion, as well as an explanation for your choice of topic (I would like to know why a particular question is more interesting to you than some others). I will also expect you to elaborate on how the theological and philosophical positions proposed in Haught’s and Polkinghorne’s books relate to your arguments.

The paper should be 8-10 pages long, and will be due on the first day of finals week. The specific claims and opinions that you choose to express in the essay are entirely up to you (bear in mind that agreeing with me won’t get you any extra points!). You will be graded on the quality of your arguments and your understanding of the material discussed in class (in particular, Learning Outcomes 5 – 9). Writing skills such as clarity, grammar, and style do matter, and will be a factor in my grading.
ONLINE DISCUSSIONS AND CLASS PARTICIPATION. Each of the weekly theological questions will require some preliminary reading on your part (the relevant sections of the lecture notes are indicated in the syllabus). Although I will review these topics and clarify the main concepts, I will expect you to come prepared.

The emphasis in this component of the course will be on class discussions and participation in the online forum. In order to get credit, you will have to post your views on six different topics, according to the following schedule:

- Topic 1: Week 1
- Topic 2: Weeks 2-3
- Topic 3: Weeks 4-5
- Topic 4: Weeks 6-8
- Topic 5: Week 9
- Topic 6: Week 10

In each of the postings, you will be expected to address one of the assigned questions (or several, if you wish), and respond to at least one other person’s posting.

The amount of credit given for this component (from 0 – 15%) will depend both on the frequency and the quality of the postings, as well as your activity in class. Note that the topics for the first and last online discussion are fixed. In the other discussions, you can choose from a range of suggested questions.

LECTURES

Week 1  
An overview of linear systems  
*Theological Topic:* Faith, reason and analogical thinking  
(Reading: Sections 1.1 and 1.2)

Week 2  
Overview of linear systems (ctd.)  
*Theological Topic:* Unknowable truths in science and mathematics  
(Reading: Section 9.1)

Week 3  
Some basic properties of nonlinear systems  
*Theological Topic:* Unknowable truths in science and mathematics (ctd.)  
(Reading: Section 9.1)

Week 4  
Basic properties of nonlinear systems (ctd.). Trademarks of chaos.  
*Theological Topic:* The attributes of God  
(Reading: Sections 9.2 – 9.3)

Week 5  
Bifurcations and bifurcation diagrams.  
*Theological Topic:* Goodness, omniscience and omnipotence  
(Reading: Section 9.4)
Week 6  Routes to chaos. Chaos in physical systems.

_Theological Topic:_ Miracles
(Reading: Section 10.1)

Week 7  Formal systems and metamathematics.

_Theological Topic:_ Evolution
(Reading: Section 10.3)

Week 8  Midterm Exam

_Theological Question:_ Religious pluralism
(Reading: Section 10.4)

Week 9  Gödel’s theorem and its consequences.

_Theological Question:_ Ethics, science and theology
(Reading: Sections 8.1 – 8.3)

Week 10  Gödel’s theorem and its consequences (ctd.)

_Theological Question:_ Aesthetics, science and theology
(Reading: Sections 7.1 – 7.3)

**PATHWAY INFORMATION**

This course is associated with the “Paradigm Shifts and the Nature of Human Knowing” pathway. If you declare a pathway in this area you may use a representative piece of work from this course in the Pathway Portfolio that you will complete during your senior year. It is recommended that you keep electronic copies of your work.

**GENERAL INFORMATION**

**OFFICE:** Engineering Center, Room 223  
**OFFICE HOURS:** Tuesdays and Thursdays, 4:00-5:00, and by appointment.  
**PHONE:** (408) 554-2394  
**E-MAIL:** azecevic@scu.edu  
**WEBSITE:** [http://www.engr.scu.edu/~azecevic/](http://www.engr.scu.edu/~azecevic/)
Academic Integrity Pledge:

“I am committed to being a person of integrity. I pledge, as a member of the Santa Clara University community, to abide by and uphold the standards of academic integrity contained in the Student Conduct Code.”

Disabilities Resources:

To request academic accommodations for a disability, students must be registered with Disabilities Resources, located in Benson, room 216. In order to register, please go online to [www.scu.edu/disabilities](http://www.scu.edu/disabilities). You will need to register and provide professional documentation of a disability prior to receiving academic accommodations. It is best to read “Required Documentation” on the website before starting the registration process in order to determine what is needed. You may contact Disabilities Resources at 408-554-4109 if you have questions.

To be in compliance with Title IX and the ADA/Section 504, a school must offer appropriate accommodation to a student whose absence is related to pregnancy or childbirth. If you are in need of an accommodation, contact the professor at the beginning of the course so that arrangement can be made. The student must also contact Disability Resources (DR) at (408) 554-4109 or [www.scu.edu/disabilities](http://www.scu.edu/disabilities) to register for accommodations.

Santa Clara University upholds a zero tolerance policy for discrimination, harassment and sexual misconduct. If you (or someone you know) has experienced discrimination or harassment including sexual assault, domestic and dating violence or stalking, we encourage you to tell someone what happened promptly. For more information, please go to [www.scu.edu/studentlife](http://www.scu.edu/studentlife) or contact the university's EEO and Title IX Coordinator, Belinda Guthrie at 408-554-4113 or by email at bguthrie@scu.edu. Look at: [http://www.scu.edu/affirmativeaction/compliancelinks.cfm](http://www.scu.edu/affirmativeaction/compliancelinks.cfm).