How Did Math Begin to Rule?

Andrei Rodin

Penrose's Triangle (first conceived by the Swedish artist Ascar Reutersvärd in 1934)

Eugene Wigner (1902-1995)

1960 : The Unreasonable Effectiveness of Mathematics in Natural Sciences

1962 : Cuban Missile Crisis

HOW DID MATH BEGIN TO RULE? SCIENCE FROM HISTORICAL AND PHILOSOPHICAL PERSPECTIVES — SPRING 2024

Contact Information:
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Course Description: The course explores the role of mathematics in sciences, technology and practical life from historical and epistemological perspectives. A special emphasis is made on the emergence of Modern mathematically-laden science and experimental method in the 16th and 17th centuries. The relevance of of these historical conceptual developments in todays science and technology is stressed and explained. The course aims at showing how the major philosophical controversies about science, mathematics and their roles in the society developed during the Early Modern period remain instrumental in todays debates about data-driven research, machine learning, mathematical biology and some other hot scientific and technological topics. The course is organised around the question famously posed back in 1960 by physicist Eugene Wigner: How to explain that mathematics is so "unreasonably" effective outside its proper domain? The course has no prerequisites and can be used as a historical introduction to a systematical course in Philosophy of Science, Philosophy of Mathematics and Philosophy of Engineering.

Course Goals:

(1) To learn about the role of mathematics in the history of civilisation, science and technology;

(2) To acquire an understanding of the concept of Modern science and its historical emergence in the 16th and 17th centuries, and the place of mathematics in the Modern science;

(3) To acquire an understanding of today's mathematically-laden science and technology from the historical and epistemological viewpoints;

(4) To develop oral and written skills for taking part in historical, epistemological and sociological discussions about science and mathematics.

Time and Place: online via osun.brightspace.com (further details will be provided)

Office Hours: TBA

Grading in the course:

- Class attendance and participation - 15 percents
- Midterm exam (a short essay of 500-1000 words on a given topic) - 15 percents
- Individual projects (the topic needs professor's approval) - 25 percents
- Final paper (a longer essay of 3500 - 5000 words resulting from a student's individual project) - 50 percents.

Course outline by weeks:

Week 1: Mathematics, Natural Sciences and Technology. The "unreasonable" effectiveness of Mathematics.
Reading: Eugene Wigner, The Unreasonable Effectiveness of Mathematics in the Natural Sciences, *Communications in Pure and Applied Mathematics*, Vol. 13, n.1 (February 1960), p. 1-14, New York, John Wiley and Sons;

Week 2: Neolithic Mathematics and Astronomy. History of Calendars. Mathematics in Ancient Egypt and Mesopotamia.
Reading: Caleb Everett, Numbers and the Making of Us, Harvard University Press, 2017, p. 1-28

Week 3: The emergence of theoretical Mathematics. Plato and Euclids Elements.
Reading: Plato, *Republic*, Book 7

Week 4: Applied Mathematics in Antiquity. Archimedes, Eratosthenes, and Ptolemy. Saving Phenomena.
Reading: Cynthia Stokes Brown, Measuring the Circumference of the Earth, `https://www.khanacademy.org/humanities/big-history-project/solar-system-and-earth/knowing-solara/eratosthenes-of-cyrene`

Week 5: Medieval and Renaissance Science. Logic and Mathematics in the foundations of Science. Aristotelian Physics.
Reading: Edward Grant, review of: Marshall Clagett (ed. and tr.), edited with an introduction, English translation and commentary by Marshall Clagett. University of Wisconsin Press: Madison, Milwaukee, 1968; and London, 1969, *Studies in History and Philosophy of Science*, Vol. 3, n. 2, p. 167-182, `https://www.sciencedirect.com/science/article/pii/0039368172900222`

Week 6: Emergence of Modern Science 1: Kepler, Copernicus, Galileo and the mathematisation of Physics.

Reading: Galileo, *Dialogue Concerning the Two Chief World Systems — Ptolemaic and Copernican*

Week 7: Emergence of Modern Science 2: Cartesian Physics and Mathematical Modelling.
Reading: Descartes, *The World*

Week 8: Emergence of Modern Science 3: Francis Bacon and the Experimental Method.
Reading: Bacon, *New Atlantis*

Week 9: Emergence of Modern Science 4: Newton and his *Principia*.
Reading: Newton, *Principia, Scholium*

Week 10: Newton, Kant and Scientific Realism.
Reading: Michael Friedman, *Kant and the Exact Sciences, Introduction*, Harvard University Press, 1992

Week 11: Science and the rise of "abstract" mathematics. Non-Euclidean geometries.
Reading: Norman Daniels, Lobachevsky: Some Anticipations of Later Views on the Relation between Geometry and Physics, *Isis*, Vol. 66, n.1 (March 1975), p. 75-85.

Week 12: Applications of Mathematics in Science beyond Physics. The unreasonable *in*effectiveness of mathematics in biology.
Reading: Arezoo Islami and Giuseppe Longo, Marriages of Mathematics and Physics: A Challenge for Biology, *Progress in Biophysics and Molecular Biology*, Vol. 106, n.3, (December 2017), p. 474-484

Week 13: Mathematics, Thought-Experiments, and Engineering.
Reading: Irina Starikova and Marcus Giaquinto, Thought Experiments in Mathematics `http://philsci-archive.pitt.edu/12823/`

Week 14: Data-driven science and Theoretical Physics: the Empiricism-Rationalism Debate in today's setting.
Reading: Chris Anderson, The End of Theory, *Wired Magazine*, June 2008 `https://www.cs.hmc.edu/twiki/pub/CS5/Reading1Gold/end_of_theory.pdf`

Week 15: Pure and Applied Mathematics Today. Concluding discussion.
Reading: Andrei Rodin, Voevodsky's Unfinished Project: Filling the Gap between Pure and Applied Mathematics, *BioSystems*, Vol. 204 (2021), 104391.

Week 16: Presentation of student projects