

History of Science 325
History of Physics: The Classical Period
Fall 2004

1:00-2:15 TR, 214 Ingraham

Instructor: Richard Staley

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This course surveys the history of physics and related sciences from the seventeenth to the end of the nineteenth century, setting the development of the ideas and methods of "classical" science in social and cultural context. Topics include the emergence of an experimental methodology, mechanics and the Newtonian world view, the history of optics, electricity and magnetism, and thermodynamics. We will trace the interplay of idea and experiment, image and machine across the library, laboratory, exhibition-hall and factory in exploring the changing relations between science and technology, science and religion, and science and the state. Our aim will be to explain the role of the physical sciences in the emergence of the modern industrial world, and to build an understanding of key factors in the vibrant – and troubled – ferment of human knowledge and society circa 1900.

Book List (University Bookstore)

Crosbie Smith, *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain* (Chicago: University of Chicago Press, 1998)

Course Reader

Available for \$28.00 from the History of Science Department Office, 7143 Social Science. Please note that refunds cannot be offered even if the class is dropped. The office is open from 7:30 a.m. - 3:10 p.m. daily, and for extended hours until 9/17.

Assessment

Assessment is through three take-home essay exams written on selected topics (75% of the total grade), and discussion participation (25%). The participation grade will test your comprehension of both lectures and readings, and will be based in part on the completion of 6 short discussion pieces in the course of the semester (see below).

First Take-Home Exam (20%): Distributed September 30; due October 7.

Second Take-Home Exam (25%): Distributed November 9; due November 16.

Final Take-Home Exam (30%): Distributed December 14; due Wednesday, December 22.

Honors Assessment

Honors students will submit in addition a paper on a topic of their own choice (worth 20% of their overall grade), to be completed by December 9.

Discussion Pieces

As part of your section participation grade (worth 25% of the final grade), in the course of the semester I would like you to write 6 short discussion pieces of 1-2 pages (double spaced).

You are to write two in each five-week segment of the course, between the dates of October 7; November 11; and December 14.

The discussion piece is to be submitted to me before Thursday's class, preferably on Tuesday, so that I can incorporate the questions and topics you raise as appropriate. If you can't give it to me at Tuesday's meeting, please leave a copy in my mailbox by 5 p.m. on Wednesday.

Content

The discussion piece should be a forum for discussing the content and the significance of particular readings and ideas raised in class. It could involve analysis of one or more of the assigned readings; discussion of a topic raised in lectures; or a mixture of both. Write about something you find interesting, describing the argument an author has presented and evaluating the evidence they have offered. Do you agree with their point of view? Support your own opinions with concrete examples from the course materials.

The task will help focus our class discussions and will also provide helpful practice in writing.

Participation and Performance

If you have a conflict between an academic requirement and any religious observance, please notify me of the specific dates concerned within the first two weeks of the course and I will find an alternative means for you to fulfill the requirement. Such requests are confidential.

In compliance with the Americans with Disabilities Act, I will make every effort to honor requests for reasonable accommodations made by individuals with disabilities. (If you think you qualify for accommodation, please contact the McBurney Disability Resource Center [263-2741; <http://jumpgate.acadsvcs.wisc.edu/~mcburney/>] to establish your eligibility for services.) Requests for accommodation can be responded to more effectively if I receive them as far in advance as possible, preferably at the beginning of the semester. Such requests are confidential.

If any problems arise, either academic or personal, that might jeopardize your performance in the course, you must try to inform me of the problem at the next available office hour, or by leaving a message with the Department of the History of Science (262-1406).

Syllabus

Apart from references to **Smith's** *The Science of Energy*, all material is in the Course Reader. The readings listed are core material and ideally should be read before the relevant lecture.

Part I: Newton's Legacy and Enlightenment Science

Sep. 2 Introductions

Discussion Topic: Introductions

Sept. 7 Light and the Methods of Natural Philosophy

Isaac Newton, "A New Theory About Light and Colours," (1672), and Queries 28 and 29 from *Optics* (4th ed., 1730) as excerpted in William Francis Magie, ed. *A Source Book in Physics* (Cambridge, MA: Harvard University Press, 1963), pp. 298-308.

Isaac Newton, *Principia Mathematica Philosophiae Naturalis* (1687), as excerpted in Magie, *A Source Book*, pp. 30-46.

John Roche, "Newton's *Principia*," in John Fauvel, Raymond Flood, Michael Shortland and Robin Wilson, eds. *Let Newton be!* (Oxford: Oxford University Press, 1988), pp. 43-63.

Sept. 9 Newton's *Principia* and *Optiks* as Models for Natural Philosophy

Casper Hakfoort, "Newton's Optics: The Changing Spectrum of Science," in Fauvel, et al. *Let Newton be!*, pp. 81-101.

Albert Einstein, "Isaac Newton," in the *Manchester Guardian*, March 19, 1927, as reprinted in Annual Report of the Smithsonian Institution, 1927, pp. 201-207.

Discussion Topic: Newton's Legacy

Sept. 14 Enlightenment Science: Electricity on Display

Thomas L. Hankins, *Science and the Enlightenment* (Cambridge: Cambridge University Press, 1985) chap. 3, pp. 46-78.

Sept. 16 Coulomb's Quantification and Volta's Current

On Robison and Coulomb see J.L. Heilbron, *Electricity in the 17th and 18th Centuries: A Study in Early Modern Physics* (Mineola, NY: Dover, 1999), pp. 465-477.

Giuliano Pancaldi, "Appropriating Invention: The Reception of the Voltaic Battery in Europe," in Marie-Noelle Bourget, Christian Licoppe and H. Otto Sibum, eds. *Instruments, Travel and Science: Itineraries of Precision from the Seventeenth to the Twentieth Century* (London: Routledge, 2002), pp. 126-55.

For an overview linking Coulomb and Galvani and Volta, see Heilbron, *Electricity*, "Preface to the Dover Edition," pp. xi-xxv.

Note Rosh Hashanah

Discussion Topic: Enlightenment Physics

Sept. 21 Chemistry in the Enlightenment

Hankins, *Science and the Enlightenment*, Chap. 4, pp. 81-112.

Sept. 23 Balancing Acts: The Chemical Revolution

Antoine-Laurent Lavoisier, *Elements of Chemistry in a New Systematic Order, Containing All the Modern Discoveries*, trans. Robert Kerr (New York: Dover, 1965), Preface and Part 1, Chap. 1, pp. xiii-xxxvii and 1-25.

Frederic L. Holmes, "The 'Revolution in Chemistry and Physics:' Overthrow of a Reigning Paradigm or Competition between Contemporary Research Programs?," *Isis* 91 (2000), 735-753.

Discussion Topic: Enlightenment Chemistry

Sept. 28 Laplacian Physics

Robert Fox, "Laplacian Physics," in Olby, et al., eds. *Companion to the History of Modern Science*, pp. 278-294.

Sept. 30 Joseph Fourier and a New Science of Heat

Eugene Frankel, "J.B. Biot and the Mathematization of Experimental Physics in Napoleonic France," *Historical Studies in the Physical Sciences* 8 (1977), 33-72.

Robert Marc Friedman, "The Creation of a New Science: Joseph Fourier's Analytical Theory of Heat," *Historical Studies in the Physical Sciences* 8 (1977), 73-99.

Note: First Take-Home Exam Distributed

Discussion Topic: Mathematization and the Sciences of Heat

Part 2: The Romantic Transformation

Oct. 5 Alexander von Humboldt and the Geosciences

Michael Dettelbach, "Humboldtian Science," in Nicholas Jardine, James A. Secord and Emma C. Spary, eds. *Cultures of Natural History* (Cambridge: Cambridge Univ. Press, 1996), pp. 287-304.

L. Pearce Williams, *The Origins of Field Theory* (New York: Random House, 1966), Chap. 2, pp. 32-63.

Oct. 7 Romantic Science

Mary Shelley, *Frankenstein, or, The Modern Prometheus* (New York: Doubleday, 1999), pp. 55-76.

Christopher Lawrence, "The Power and the Glory: Humphry Davy and Romanticism," in Andrew Cunningham and Nicholas Jardine, eds. *Romanticism and the Sciences* (Cambridge: Cambridge Univ. Press, 1990), pp. 213-227.

Note: First Take-Home Exam Due

Discussion Topic: Romantic Science

Oct. 12 Ampère and Faraday's Lines of Force

Williams, *Origins of Field Theory*, Chap. 3, pp. 64-91.

David Gooding, "'In Nature's School': Faraday as an Experimentalist," in David Gooding and F.A.J.L. James, eds. *Faraday Rediscovered* (Basingstoke: Macmillan, 1985), pp. 105-135.

Oct. 14 On Making Facts and Machines

Iwan Morus, "Different Experimental Lives: Michael Faraday and William Sturgeon," *History of Science* 30 (1992), 1-28.

Discussion Topic: Cultures of Experiment in Faraday's London

Part 3: The Science of Energy and the Growth of Laboratory Physics

Oct. 19 James and William Thomson: Recovering the Motive Power of Heat

Crosbie Smith, *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain* (Chicago: University of Chicago Press, 1998), Introduction and Chap. 3, pp. 1-14 and 31-52.

Oct. 21 James Joule's Mechanical Value of Heat

Smith, *The Science of Energy*, Chap. 4, pp. 53-76.

Heinz Otto Sibum, "Reworking the Mechanical Value of Heat: Instruments of Precision and Gestures of Accuracy in Early Victorian England," *Studies in History and Philosophy of Science* 26 (1995), 73-106.

Discussion Topic: Joule's Manchester

Oct. 26 Progress and Energy

Smith, *The Science of Energy*, Chaps. 5-7, pp. 77-149.

Oct. 28 Thermodynamics

T.S. Kuhn, "Energy Conservation as an Example of Simultaneous Discovery," in Marshall Clagett, ed. *Critical Problems in the History of Science* (Madison: University of Wisconsin Press, 1959), pp. 321-356.

Smith, *The Science of Energy*, Chap. 8, pp. 150-169.

Discussion Topic: The Science of Thermodynamics

Nov. 2 The Treatises and the New Natural Philosophy

Smith, *The Science of Energy*, Chaps. 10-12, pp. 192-267.

Nov. 4 Cables and Field Theory

Smith, *The Science of Energy*, Chap. 13, pp. 268-287.

Bruce J. Hunt, "Doing Science in a Global Empire: Cable Telegraphy and Electrical Physics in Victorian Britain," in Bernard Lightman, ed. *Victorian Science in Context* (Chicago and London: The University of Chicago Press, 1997), pp. 312-333.

Discussion Topic: Electromagnetism and Empire

Nov. 9 Maxwell's Cavendish Laboratory: Teaching Experimental Physics

James Clerk Maxwell, "Introductory Lecture on Experimental Physics," in *The Scientific Papers of James Clerk Maxwell*, ed. W.D. Niven (Cambridge: Cambridge Univ. Press, 1890), 241-255.

Simon Schaffer, "Late Victorian Metrology and Its Instrumentation: A Manufactory of Ohms," in Mario Biagioli, ed. *The Science Studies Reader* (New York and London: Routledge, 1999), pp. 457-478.

Graeme Gooday, "Precision Measurement and the Genesis of Physics Teaching Laboratories in Victorian Britain," *British Journal for the History of Science* (23) 1990, 25-51.

Note: Second Take-Home Exam Distributed

Nov. 11 Writing Review and Essay Preparation

Discussion Topic: The Laboratory Revolution

Nov. 16 Rowland, Michelson and Physics in the U.S.

Daniel J. Kevles, *The Physicists: The History of a Modern Scientific Community in America* (Cambridge, MA and London: Harvard University Press, 1995), pp. 25-74.

Note: Second Take-Home Exam Due

Nov. 18 Light and Mechanics: Testing Relative Motion

H.A. Rowland, "Plane and Concave Gratings," (1882) as excerpted in Magie, *Source Book*, pp. 365-368.

A.A. Michelson and E.W. Morley, "On the Relative Motion of the Earth and the Luminiferous Ether," (1887) as excerpted in Magie, *Source Book*, pp. 369-377.

H.A. Rowland, "The Highest Aim of the Physicist," (1899) in Spencer R. Weart, ed. *Selected Papers of Great American Physicists* (New York: American Institute of Physics, 1976), pp. 91-103.

Discussion Topic: Physics in the U.S.

Part 4: The New Physics

Nov. 23 The Discoveries: Roentgen's X-rays

Abraham Pais, *Inward Bound: Of Matter and Forces in the Physical World* (New York: Oxford University Press, 1986), Chaps. 2-4, pp. 35-91.

W.C. Roentgen, "On a New Kind of Rays," *Nature* 53 (23.1.1896), 274-276 and A.A.C. Swinton, "Professor Röntgen's Discovery," *Nature* 53 (23.1.1896), 276-277.

Thanksgiving: No Lecture Nov. 25

Nov. 30 The Discoveries: Radioactivity

Henri Becquerel, excerpt on "The Radiation from Uranium," *Comptes Rendus* 122 (1896), p. 420 as translated in W.F. Magie, *A Source Book in Physics* (Cambridge, MA: Harvard University Press, 1963), pp. 610-613

P. and M.S. Curie, excerpts on "Polonium," and "Radium," *Comptes Rendus* 127 (1898), pp. 175 and 1215, as translated in Magie, *Source Book*, pp. 613-616.

Helena Pycior, "Reaping the Benefits of Collaboration while Avoiding Its Pitfalls: Marie Curie's rise to Scientific Prominence," *Social Studies of Science* 23 (1993), 301-323.

Dec. 2 New Directions in Theory: Questioning the Foundations

Ernst Mach, "The Economical Nature of Physical Inquiry," in *Popular Scientific Lectures*, trans. Thomas J. Mc-Cormack, (La Salle, IL: Open Court, 1986), 186-213.

Christa Jungnickel and Russell McCormack, *Intellectual Mastery of Nature: Theoretical Physics from Ohm to Einstein*. 2 vols, Vol. 2, (Chicago and London: The University of Chicago Press, 1986), pp. 211-245.

Discussion Topic: New Directions: Microphysics

Dec. 7 Black-Body Radiation and the Interrelations between Theory, Experiment, and Interpretation

J.L. Heilbron, *The Dilemmas of an Upright Man: Max Planck as Spokesman for German Physics* (Berkeley: University of California Press, 1986), pp. 1-28.

David Cahan, "High Temperatures and High Science," in *An Institute for an Empire: The Physikalisch-Technische Reichsanstalt, 1871-1918* (Cambridge: CUP, 1989), pp. 143-157.

Dec. 9 Constituting a Community: The Inaugural International Congress of Physicists, Paris, 1900

Henri Poincaré, *Science and Hypothesis* (London: Walter Scott, 1905), "Hypotheses in Physics," and "The Theories of Modern Physics," pp. 140-182.

Henry Adams, *The Education of Henry Adams: An Autobiography*. Edited by Henry Cabot Lodge (Boston and New York: Houghton Mifflin Company, 1918), pp. 376-391.

Discussion Topic: Physical World Views and the International Community

Dec. 14 On the Co-Creation of Classical and Modern Physics

Ludwig Boltzmann, "On the Development of the Methods of Theoretical Physics in Recent Times (1899)," in *Theoretical Physics and Philosophical Problems: Selected Writings*. Edited by Brian McGuinness (Dordrecht and Boston: D. Reidel, 1974), pp. 77-100.

Note: Final Take-Home Exam Distributed

Wednesday Dec. 22 Final Examination Due (12:25-2:25 P.M.)

