

History of Science 325

History of Physics: The Classical Period

Spring 2002

1:20 p.m. MWF, 6228 Social Sciences

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Office Hours: 2:30-3:30 p.m. M, 4-5 p.m. R

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 \$30.50 from the History of Science Department Office, 7143 Social Science. Note that the office is open from 7:30 a.m. - 3:15 p.m. daily.

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.

First Take-Home Exam (20%): Distributed February 22; due March 1.

Second Take-Home Exam (25%): Distributed April 5; due April 12.

Final Take-Home Exam (30%): Distributed May 8; due Thursday, May 16.

4th Credit and Honors Assessment

4 credit and 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 May 3.

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

Jan. 23 Introduction

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.

Jan. 25 Discussion: Introductions

Jan. 28 Newton's *Principia* as a Model for Mathematical Natural Philosophy

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.

Jan. 30 Newton's *Optiks* as a Model for Experimental 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.

Feb. 1 Discussion: Newton's Legacy

Feb. 4 Enlightenment Science: Electricity on Display

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

Feb. 6 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, forthcoming 2002), pp. 1-38.

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

Feb. 8 Discussion: Enlightenment Physics

Feb. 11 Chemistry in the Enlightenment

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

Feb. 13 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.

Feb. 15 Discussion: Enlightenment Chemistry

Feb. 18 Laplacian Physics

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

Feb. 20 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.

Feb. 22 Discussion: Mathematization and the Sciences of Heat

Note: First Take-Home Exam Distributed

Part 2: The Romantic Transformation

Feb. 25 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.

Feb. 27 Romantic Science: Oersted's Discovery of Electricity

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.

H.A.M. Snelders, "Oersted's Discovery of Electromagnetism," in Andrew Cunningham and Nicholas Jardine, eds. *Romanticism and the Sciences* (Cambridge: Cambridge University Press, 1990), pp. 228-240.

Mar. 1 Discussion: Romantic Science

Note: First Take-Home Exam Due

Mar. 4 Faraday and the Line 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.

Mar. 6 On Making Facts and Machines

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

Mar. 8 Discussion: *Cultures of Experiment in Faraday's London*

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

Mar. 11 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.

Mar. 13 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.

Mar. 15 Discussion: *Joule's Manchester*

Mar. 18 Progress and Energy

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

Mar. 20 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.

Mar. 22 Discussion: *The Science of Thermodynamics*

Mar. 23-31 Spring Recess

Apr. 1 The *Treatises* and the New Natural Philosophy

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

Apr. 3 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.

Apr. 5 Discussion: Electromagnetism and Empire

Note: Second Take-Home Exam Distributed

Apr. 8 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.

Apr. 10 Hertz's Discovery

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.

Jed Z. Buchwald, "How Hertz Fabricated Helmholtzian Forces in His Karlsruhe Laboratory or Why He Did Not Discover Electric Waves in 1887," in Lorenz Krüger, ed. *Universalgenie Helmholtz: Rückblick nach 100 Jahren* (Berlin: Akademie Verlag, 1994), pp. 43-65.

Apr. 12 Discussion: The Laboratory Revolution

Note: Second Take-Home Exam Due

Apr. 15 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.

Apr. 17 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.

Apr. 19 Discussion: Physics in the U.S.

Part 4: The New Physics

Apr. 22 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.

Apr. 24 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.

*Apr. 26 Discussion: New Directions in Experiment: Microphysics**Apr. 29 New Directions in Theory: The Electromagnetic World View*

Ernst Mach, "The Economical Nature of Physical Inquiry," in *Popular Scientific Lectures*, trans. Thomas J. McCormack, (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.

May 1 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.

*May 3 Discussion: New Directions in Theory: Physical World Views**May 6 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.

May 8 Classical and Modern Physics

J.L. Heilbron, "Fin-De-Siecle Physics," in Carl Gustaf Bernhard, Elisabeth Crawford and Per Sörbom, eds. *Science, Technology and Society in the Time of Alfred Nobel* (Oxford: Nobel Foundation, 1982), pp. 51-73.

Note: Final Take-Home Exam Distributed

*May 10 Discussion: An International Community?**May 16 Final Examination Due*