SYLLABUS: LEONARDO AND THE ART OF ENGINEERING

STS-UY 3904 Special Topic in Science and Technology Studies
(Also a Humanities and Social Sciences Elective), 4 Credits
Department of Technology, Culture & Society

SPRING 2016

Dr. Matthew Landrus and Dr. Maurizio Porfiri

Mondays & Wednesdays 12:30 – 2:20 pm, JAB 678

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Dr. Maurizio Porfiri, mporfiri@nyu.edu; Office: RH507; tel. 646-997-3681; Office Hours: Monday, 2:30-3:30 pm and by appointment

Prerequisites: Completion of first year writing requirements EXPOS-UA 1 Writing the Essay and EXPOS-UA 2 The Advanced College Essay

Description
This course frames Leonardo da Vinci’s work as an engineer and natural scientist within the context of activities among his notable engineering contemporaries. With particular attention to civil and military engineering, the course addresses pre-modern and early modern practical and theoretical solutions to problems in mechanics, engineering, early physics, and the natural sciences. In this manner, and with reference to Leonardo’s work, the course examines traditional and intellectual careers of “practical men” of the technical arts, expanding on their training in mathematics, geometry, the other arts, natural sciences and court culture, to assess their inventive and celebrated engineering strategies. The structure of the course will comprise of readings, lectures, hands-on demonstrations and discussions of Leonardo da Vinci’s work, while also assessing the approaches of his predecessors, contemporaries, and followers. Modern elements of mechanics and engineering will be presented to help evaluate Leonardo’s contribution and assess its value.

Course Objectives
The purpose of the course is to expand and develop your observational, analytical, research, and vocabulary skills when examining the investigative and inventive engineering and natural science projects of Leonardo, his predecessors, contemporaries, and followers. Beyond the study of technical and scientific contributions, the course will also introduce theories, purposes, and methods of the history and philosophy of early modern concepts of science. The main objectives of the class are:

- To understand and evaluate important materials and methods used by Leonardo and associated engineers and natural scientists to engage in a more scientific manner with their work and environments.
- To address assessments of meaning in works of early modern engineers and natural scientists that crossed disciplines, so that their methods compared with those of visual artists for painting or sculpture.
- To obtain a visual and intellectual knowledge of major works of early modern engineering and natural science – focusing on Leonardo’s work - that resulted from direct engagements with science-related methods and knowledge.
- To address the historical, social, political, and intellectual contexts of these works as a means of understanding the concepts shaping the approaches of engineers and natural scientists.
To understand the reception of Leonardo’s work until the present time and develop an individual critical assessment on the basis of our current training in science and engineering.

To reconstruct and reverse-engineer some of Leonardo’s inventions through rapid prototyping and computer-aided design.

**Required Readings**


**Exams**

Your comprehension of this material will be assessed with exam essays, theoretical and hands-on technical engineering problems, and in-class presentations, which will also develop your research skills and promote the development of analytic and critical thinking. There will be two mid-term exams and one final project. The mid-term exams will be administered in class and will test the student’s comprehension and ability to apply material learned in class and through assignments. Mid-term exams are in-class, closed books, closed notes. Every page of every exam submission should have the student full name and section number. Illegible work and loose sheets will not be graded. Students must complete the exam on their own. The final project will consist of a written essay and an in-class presentation, featuring original prototypes built on the basis of Leonardo’s work. The presentation will last ten minutes, delivered extemporaneously. The essay should be based on rigorous bibliographic research and the prototyping component should demonstrate the overarching idea of the project. Before the day of your presentation you are required to email your presentation to mhl8@nyu.edu and mporfiri@nyu.edu, along with requisite computer files for generating the prototypes (possibly as a link). The presentation should be in a Keynote or Powerpoint format, and the attachment should be emailed with its suffix, ending in .key, or .pptx. The essay must consist of approximately 5000 words.

**Class Attendance and Absences**

You are expected to actively participate in class lectures (attendance is essential because lectures will cover topics and issues not addressed in the readings). An unexcused absence will result in the loss of half of your class participation grade. An absence may only be excused with an acceptable submission of a doctor’s note as evidence of the unavoidable circumstance, such as a hospital emergency room visit at the time of the class. You must earn the class participation grade, which is for genuine class discussions. An occasional brief comment or question is not sufficient engagement. This course component is assessed not simply on the volume of your participation but especially on the quality and thoughtfulness of your contribution in class. Questions and ideas are welcome. You should always be on time; late arrivals disrupt the class. There are no opportunities for extra credit. Arriving noticeably late to class, or leaving class early will cause the class participation grade to be reduced by a half. You should not use computers or cell phones in class, unless asked to do so.

**Honor System**

The honor system is in strictly enforced for this course. It is assumed that all work submitted by a student is done so under the honor system code.

**Grading Policy**
Participation: 10%
Mid-term 1: 25%
Mid-term 2: 25%
Final project: 40%

List of Topics

1] 25 Jan   Introductory and Overview
           (Monday, ML and MP), Read: Nanni, pp. 9-11 (Foreword)

2] 27 Jan   Introduction to Leonardo and pyramidal law
           (Wednesday, ML), Read: Kemp, pp. 1-21

3]  1 Feb   The disputation about the arts in the mirror of Angelo Poliziano’s Panepistemon
           (Monday, ML), Read: Nanni, pp. 15-29

4]  3 Feb   Rapid protoyping
           (Wednesday, MP)

5]  8 Feb   Leonardo’s art and engineering in the 1470s and early 1480s
           (Monday, last day to drop/add, ML), Read: Kemp, pp. 22-70

6] 10 Feb   *Machinae ad majestate imperii* and textile manufacturing machines
           (Wednesday, ML), Read: Nanni, pp. 31-53

8] 17 Feb   Leonardo’s engineering proposals at the Sforza Court
           (Wednesday ML), Read: Kemp, pp. 71-106

9] 22 Feb   Leonardo as court engineer at the Sforza Court
           (Monday, ML), Read: Kemp, pp. 106-161

10] 24 Feb  Changes in the structure of the “practice of geometry” between Piero della Francesca and Leonardo
          (Wednesday, ML), Read: Nanni, pp. 55-85

11] 29 Feb  Mid-term 1
          (Monday, ML)

12]  2 Mar   Mechanics and machine models between the fifteenth and seventeenth centuries
           (Wednesday, ML), Read: Nanni, pp. 87-133

13]  7 Mar   Leonardo as court engineer in the 1490s
           (Monday, ML), Read: Kemp, pp. 161-203

14]  9 Mar   The pluralism of conventions: drawing machines between the Middle Ages and the Renaissance
           (Wednesday, ML), Read: Nanni, pp. 135-161

15] 21 Mar   Leonardo’s independent career as an engineer
           (Monday, ML), Read: Kemp, pp. 205-270
16] 23 Mar  Leonardo’s later career, c. 1508-19
(Wednesday ML), Read: Kemp, pp. 272-348

17] 28 Mar  In search of a lexicon of machines
(Monday, MP), Read: Nanni; Biffi, pp. 165-175

18] 30 Mar  Scientific instruments
(Wednesday, MP), Read: Hart, pp. 13-34

19] 4 Apr  Statics
(Monday, MP), Read: Hart, pp. 99-142

20] 6 Apr  Statics
(Wednesday, MP), Read: Hart, pp. 99-142

21] 11 Apr  Dynamics
(Monday, MP), Read: Hart, pp. 75-95

22] 13 Apr  Dynamics
(Wednesday, MP), Read: Hart, pp. 75-95

25] 18 Apr  Mid-term 2
(Monday, MP)

26] 20 Apr  Kinematics of machines
(Wednesday, MP)

27] 25 Apr  Flying machines
(Monday, MP)

29] 27 Apr  The source and reception of Leonardo’s ideas
(Wednesday, MP), Read: Moon, pp. 44-65 and Hart, pp. 54-74

30] 2 May  An Outlook on textile, civil, and military machines
(Monday, MP)

31] 4 May  Open discussion and take-home messages
(Wednesday, ML and MP)

32] 9 May  Final Project
(Monday, last day of classes, MP exam)

**ABET a-k Criteria Compliance**

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(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
(1a) an ability to apply principles of engineering, basic science, and math to model, analyze, design and realize physical systems, components or processes
(1b) an ability to work professionally in both thermal and mechanical systems areas

Grading Scale

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<th>Grade</th>
<th>A: 90+</th>
<th>B+: 83+</th>
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<td>77+</td>
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Monographs

Most comprehensive approaches concentrate on Leonardo’s artistic work, his technical work, or his scientific interests. Three of the monographs included here focus on different aspects of his scientific studies (Hart 1961, Keele 1983, and Zubov 1968). Martin Kemp’s 1981 monograph remains one of the few attempts to integrate the many facets of Leonardo’s activities into a single, readable book.

  Written by a physician and medical historian, this was the first monograph to incorporate Leonardo’s anatomical studies within a general study of his approach to science.

  The English translation of Леонардо да Винчи, first published in Leningrad in 1961. One of the ranking monographs written by an historian of science, it is notable for its in-depth account of the artist’s scientific and philosophical approaches, but has only cursory references to the visual and mechanical arts.

Collections of Essays

This section includes some of the most valuable compilations developed from symposia devoted to various aspects of Leonardo’s work, arranged chronologically by date of publication. The earliest is the first edition of Baroni, Calvi, and Nicodemi’s comprehensive volume, which coincided with a famous exhibition of 1939, and its catalogue, *Mostra di Leonardo da Vinci,* noteworthy for its arrangement of technical, sculptural and pictorial projects. The book and catalogue were encouraged by Benito Mussolini who ordered the construction of 200 models of Leonardo’s engineering drawings at an expense of 4,950,000 lire (£173,027), which were exhibited with works of art in Milan. It set a precedent for volumes combining diverse subjects, like the majority of other entries in the section. Philipson 1966 includes essays by leading scholars in a variety of fields. O’Malley 1969 is unsurpassed as an introduction by major scholars to Leonardo’s scientific studies relevant to art, with articles such as Gombrich’s classic study of wind, water, and motion. Reti 1974 is especially valuable for its extensive overviews of Leonardo’s technological studies. Bellone and Rossi 1982 include important studies of Leonardo’s Trattato. The five-volume set of reprints edited by Farago 1999 provides a useful overview of article-length studies in all fields of scholarship in English. The sections on Catalogues of Permanent Collections and Exhibition Catalogues also cite collaborative publications.

  This comprehensive volume addresses all aspects of Leonardo’s work; revised in 1956 and 1980, also available in French, German, and English. Revisions include Augusto Marinoni’s essay on philology, which supersedes Luigi Sorrento’s essay in the 1939 edition, and Marco Rosci’s discussion of the Madrid Codices rediscovered in 1965.

  An anthology by leading Leonardo scholars on a diverse range of subjects, this substantial volume with twenty-five essays in Italian, French and English includes extensive appendices, indices, bibliographies, and discussions of quincentennial events.

This is one of the first selections of essays by Leonardo specialists on art and science in Europe and the US, to address “the truth concerning his ‘secrets’” (p. viii). Essays on his social status, painting, science, philosophy, and psychology include Wölfflin, Valentiner, Berenson, Read, Koyré, Sarton, De Santillana, Clark, Eissler, and Valéry.


Sponsored by the UCLA Center for Medieval and Renaissance Studies, this symposium and the resulting volume of essays by leading Leonardo and Renaissance scholars is an enduring classic that bridges the artistic and scientific sides of Leonardo’s activities.


In addition to providing a groundbreaking study of Leonardo’s technological interests on various subjects, this publication is remarkable for its “hypertext” design conceived in advance of electronic media. It is the first major study to include the Madrid Codices, rediscovered in 1965, and was meant to complement the McGraw-Hill publication of these codices in facsimile in 1974.


Eighteen essays in this substantial volume address areas of the scholars’ expertise and thereby provide a state of Leonardo scholarship in 1982. Authors include Ernst Gombrich, Martin Kemp, Pietro Marani, Aldo Scaglia, Donald Strong, Clifford Truesdell, Cesare Vasoli, and Kim Veltman.


A useful collection of writings beginning with the earliest historical descriptions and biographies, this is arranged throughout as an historiography of scholarship (all but the first volume, scholarship in English), necessarily emphasizing articles and shorter essays.

**Current Editions and English Translations of Leonardo’s manuscripts**

The Italian publisher Giunti has published the current facsimile and transcription editions of all the autograph manuscripts and drawings, superseding earlier, still reliable editions. Since the appearance of the first facsimile edition in 1894-1904, the Codex Atlanticus has been unbound, revealing new material, and the individual sheets comprising this vast scrapbook have been remounted and re-numbered. The newer facsimile edition, initially published from 1972-80, should therefore be consulted, but the other autograph manuscripts are reliable in the older editions. The electronic resource of the Comune di Vinci is the most immediate reference for scans and transcriptions of all of the manuscripts and drawings,


This is the most immediate reference for scans and transcriptions of all of the manuscripts and drawings, with the exclusion of the non-anatomical drawings at Windsor and some smaller collections. The interface is in Italian and English. Most of the other Windsor drawings by Leonardo are available at the Royal Collection website
[http://www.royalcollection.org.uk/eGallery/maker.asp?maker=12196], which are annotated and accompanied by an image detail browser.

**Manuscripts A - M**

These are individual, bound notebooks of various sizes and dates, an important legacy spanning the entire length of Leonardo’s literary career, located in the Institut de France, Paris. Ms. A (2172) includes advice on painting, perspective, architecture, study of impetus, optics, light and shadows, motion, science of weights, geometry, water, weaponry, 1490-92. Ashburnham II (2185), originally part of Ms. A, includes advice on painting, perspective, study of impetus, 1490-92. Ms. B (2173) includes notes on military science, architecture, urban planning, 1485-87. Ashburnham I (2184) includes notes on military science, architecture, 1485-87, and was originally part of Ms. B. Ms. C (2174), includes notes on lights and shadows, perspective, fluid flow, acoustics, study of impetus, weights, 1490-91. Ms. D (2175), optics, study of the eye, 1508-09 Ms. E (2176) contains notes on geometry, painting, motion, water, technology, 1513-14. Ms. F (2177) contains notes on movements and forms of water, geology, 1508-09. Ms. G (2178) contains notes on plants, lights and shadows on plants, geometry, flight of birds, study of the heart, 1510-15. Ms. H (2179) contains notes on bestiary, allegories, Latin studies, water and its effects, 1493-94. Ms. I (2180) contains notes on geometry, mechanics, motion, Latin studies, 1497. Ms. K (2181) contains notes on geometry, water, flight of birds, canalization, architecture, 1503-07. Ms. L (2182) contains notes on fluid dynamics, properties of water, statics, military and civil engineering, 1497-1502. Ms. M (2183) contains notes on geometry, falling bodies, falling water, air resistance, botany, 1495-97. The current critical edition is published by Giunti and older, still useful editions are cited under that entry. English translations by John Venerella of the all Paris manuscripts are published by the *Raccolta Vinciana* (1999 – 2003).


  These are annotated editions of Manuscripts C, D, and F.

  This is the only English edition of Manuscripts A – M.

**The Forster Codices**

These are three small pocket-size notebooks, located in the Victoria and Albert Museum, London: Forster I contains notes on plane and solid geometry, transformations of the pyramid, hydraulics, 1487-97; Forster II contains notes on the medieval science of weights, architecture, ornamental drawings theology, mathematics, 1496-97; and Forster III, records activities at Court of Milan, sketches, 1493-96.


**Codex Arundel**

This important manuscript in the British Library is comprised of three separate sets of notes bound together. It contains notes on mathematics, physics, optics, astronomy, architecture, plans for Romorantin palace, instrumentation, 1478-1519.

  

**Madrid Codices**

These two notebooks were only recently rediscovered in the Madrid National Library, in 1965. Madrid Codex I (8937) contains notes and beautiful, highly refined drawings of the elements of machines, technology of mechanisms, theoretical mechanics, 1490-1508. Madrid Codex II (8936) contains notes and sketches of fortifications, canalization, architectural studies, military engineering, optics, the Sforza equestrian monument, 1491-93, 1503-05.

  
  This is also translated by F. Chueca Goitia into Spanish; Madrid: Taurus Ediciones, 1974; and translated by Gustav Ineichen, Friedrich Klemm, Ludolf von Mackensen, and Reinhilt Richter into German; Berlin: S. Fischer, 1974.

**Codex Atlanticus**

This enormous compilation in the Biblioteca Ambrosiana, Milan, consists of approximately 1750 loose sheets of drawings and texts assembled into an album at end of the sixteenth century by the Milanese artist Pompeo Leoni. The individual sheets were mounted on 401 white sheets in a volume titled “Codice delle sue carte in forma Atlantica [atlas folio] ...disegni di machine et delle arti segreti et altre cose” (designs pertaining to machines and of the arts, secrets, and other things) around 1780. This is one of four volumes of similar size compiled by Leoni, one of which with 604 leaves containing over 1200 “drawings” and anatomical studies is now at the Windsor Royal Library, and two of which are lost. The Atlanticus folios and fragments were remounted in the 1970s on 1119 sheets, in twelve leather-bound atlas folios (60 x 44 cm.). The contents address engineering, mechanical studies, mathematics, astronomy, geography, botany, anatomy, artistic studies, Sforza equestrian monument studies, architecture, and urban plans, dating to around 1478-1519. The edition supersedes the first facsimile of the Codex Atlanticus, transcribed and annotated by Giovanni Piumati 1894-1904. Pedretti 1978 has published essential annotations and cross-references.

  
  This is a facsimile of the recently remounted folios on 1119 sheets, with twelve additional quarto volumes of transcriptions. Giunti also published a three-volume version in 2000, and in 2006 joined with newspapers, *La Reppublica* and *Il Sole 24 Ore*, to offer a twenty-volume folio set, with a preface by Carlo Pedretti and essays on the transcription and indices by Pietro Marani.

Extensive annotations, references, and dates for almost 1750 folios are in this indispensible resource.

**Codex on the Flight of Birds**
This famous notebook in the Royal Library of Turin contains studies of the flight of birds and flying machines, 1505. Ivor Hart provides an English translation in *Mechanical Investigations*, 200-235.


**Codex Leicester**
Formerly known as the Codex Hammer, this is the only privately owned autograph Leonardo manuscript, currently in the collection of Bill and Melinda Gates, Seattle. It has been the subject of numerous recent touring exhibitions. It contains notes on nature, weight, and motion of water, erosion, geology, fossils, and astronomy, 1508-10.


**Codex Trivulzianus**
This frequently published codex in the Royal Library in Turin consists of vocabulary lists, sketches for the dome of Milan cathedral, architecture, caricatures, 1478-90. An English translation by Murtha Baca was co-published by Giunti and the Johnson Reprint Corporation in New York in 1982. In addition to the current edition of the text, there has been an important interpretive exhibition curated by Marani and Piazza 2006. Another complete English translation is available in Stites 1970.

  These concurrent, equally viable editions supersede *Il Codice di Leonardo da Vinci nella Biblioteca del Principe Trivulzio in Milano*. Transcription and annotation by Luca Beltrami. Milan (n.p.), 1891. This still reliable edition is available at [Archive.org]
  http://www.archive.org/details/ilcodicedileonar00leonuoft.

  The best study of the codex, published as part of an exhibition with other manuscripts, has a CD with a transcription in PDF and a Windows application with cross-references to texts by Luigi Pulci, Roberto Valturio and Masuccio Salemitano, along with English translations of chapters in the (Italian) catalogue.

**Windsor anatomical folios, Windsor Castle, Royal Library, Windsor**

Along with the pages that comprise the Codex Atlanticus, the Windsor folios were compiled by Pompeo Leoni in Milan. Previously bound in four volumes, three of which were devoted to anatomy, the Windsor group includes over 1200 studies on anatomy, landscapes, the human figure, horses and other animals, and caricatures, dating to around 1478-1518. Of all the manuscripts that combine text and image, the anatomical manuscripts and studies of human proportions and movements deserve to be included among the writings. Leonardo intended to publish this material in book form, as he discussed with regard to anatomy on Windsor folio 19037v and as Luca Pacioli noted in 1498, that Leonardo had “finished a worthy book on painting and human movements” (*De Divina Proportione*, folio 2r). The other Windsor drawings are in the section on Drawings/Facsimiles and Catalogues of Permanent Collections.


**Treatise on Painting**

A complex document in the historical reception of Leonardo’s writings, the Treatise on Painting belongs in a class by itself. Compiled posthumously from autograph manuscripts by Francesco Melzi, a Milanese aristocrat and Leonardo’s student who accompanied him to France at the end of his life and inherited all of his teacher’s manuscripts and studio instruments. Often presumed to be simply an autograph manuscript, it is actually the first anthology of excerpted passages, establishing an editorial practice that still continues. Around the time that Melzi died (c. 1570), an anonymous editor abridged the text, in which form it circulated widely in manuscript. The treatise on painting was first published in this abridged form in 1651, and the editors made many minor alterations. The complete, unabridged text was first published in 1817, and has been the subject of extensive scholarly interest ever since. The 1651 edition has recently attracted scholarly attention from those interested in the historical reception of the artist, his writings, and the history of art academies and connoisseurship, where this text exercised a powerful influence.

**Editions and Translations**

The abridged Treatise on Painting was the first form in which Leonardo’s writings were widely known and the only form in which his ideas circulated widely before the end of the nineteenth century. The abridged manuscript was created around 1570 – 82 by an anonymous editor and, after many failed attempts, finally published in both French and Italian editions in Paris in 1651, as cited below. The original 1651 publications are available online in facsimile here [http://www.leonardodigitale.com]. There are no contemporary reprints of this text, aside from a 2005 Dover edition of a freely-rendered early nineteenth-century English translation that substantially rearranges the text. In 1817, the unabridged parent manuscript which had been recently rediscovered in the Vatican Library was published (Manzi). The first critical edition of that text was edited by Ludwig 1882, with a German translation, and the current critical edition (edited by Pedretti and Vecce 1995) is based exclusively on the unabridged text. The unabridged text is available in facsimile in McMahon’s English language edition (1956), which rearranges the order of passages in the translation. Modern editions of the first section of the unabridged text have been edited by Farago 1992 and Richter 1939; rev. ed. 1949. For
translations into languages other than English, see Mario Valentino Guffanti’s list of printed editions in the next section.

  
  The first edition of Leonardo’s writings was edited by a bibliophile who included letters of dedication; his own biography of Leonardo; a biography of Leon Battista Alberti (1404-72); Alberti’s treatises *On Painting* and *On Sculpture*; a bibliography of Alberti’s writings; and a bibliography of 35 art books. It was soon translated into all the major European languages and widely cited.

  
  Published in the same deluxe format as the Trattato della pittura but lacking the supporting material, except for two new dedicatory letters, one of them addressed to Nicolas Poussin, the leading French painter who had been commissioned to provide the illustrations for both editions.


  Rigaud’s translation was originally published in 1802 in London by J. Taylor with a new biography of Leonardo by John Sidney Hawkins.


  This is the first printed edition of the unabridged parent manuscript of the Treatise on Painting, which was rediscovered in the Vatican Library at the end of the eighteenth century.


  This English translation of the entire parent manuscript is published with a facsimile (vol. 2), extensive introduction by Heydenreich, concordances, and a bibliography (incomplete) of printed editions compiled by Kate Steinitz. The English translation rearranges the order of the passages.


  Traces Leonardo’s famous arguments in defense of painting to their intellectual sources. The earlier English translation by Irma Richter, Paragone (in Richter 1939; revised edition. London: Oxford University Press, 1949), is still useful. For other, Italian editions (including Scarpatti, 1993), see Guffanti, in Re-Reading Leonardo, 569 – 606. Passages have been widely excerpted in anthologies, including Richter, MacCurdy, and Kemp and Walker.


  This edition of the unabridged Codex Urbinas Vaticanus 1270 includes a transcription, facsimile, and extensive editorial introductions by two leading Leonardo scholars. It supersedes the edition first published by Heinrich Ludwig with a German translation [Lionardo da Vinci, Das Buch von
Reference works

Steinitz 1958 remains the foundational study for the extensive corpus of surviving manuscripts and printed editions of the abridged Trattato. Updates by Steinitz appeared periodically in the *Raccolta Vinciana* and Carlo Pedretti’s 1964 reconstruction of a lost notebook based on excerpts included in the unabridged text of the Treatise on Painting and his 1977 Commentary reviewed and added to the evidence. In 2009, Mario Valentino Guffanti published an amplified and corrected history of the printed editions in the first volume dedicated to the historical reception of this influential text. Nicolas Poussin was commissioned by Cassiano dal Pozzo to make illustrations for the printed edition that was eventually published in 1651, as discussed recently by Rosenberg and Prat 1994. Recently attention has been given to the historical reception of the text, by Marani and Fiorio 2007 and Farago 2009. References in this subsection are given in chronological order of publication for the sake of clarity in a field where information is frequently subject to revision.

- Steinitz, Kate T. *Leonardo da Vinci’s Trattato della pittura* (Treatise on Painting). A bibliography of the printed editions, 1651-1956, Copenhagen: Munksgaard, 1958. And updates are in *Raccolta Vinciana* XVIII (1960): 97-111; XX (1962): 223-254. The title is slightly misleading because a large portion of this invaluable study is devoted to cataloguing the many manuscript copies that Steinitz autopsied. Her notes, microfilms, and photographs are on deposit at the Elmer Belt Library of Vinciana, UCLA, Los Angeles.

- Pedretti, Carlo. *Leonardo da Vinci on Painting: A Lost Book (Libro A), reassembled from the Codex Vaticanus Urbina 1270 and from the Codex Leicester*. Berkeley: University of California Press, 1964. This reconstruction of a lost notebook is important for showing how Leonardo organized ideas for a treatise on painting that he intended to write. See also: Martin Kemp and Juliana Barone, “What might Leonardo’s own Trattato have looked like? And what did it actually look like up to the time of the editio princeps?,” in *Re-Reading Leonardo*, 2009, 39-60.

- Pedretti, Carlo. “Introduction.” In *The Literary Works of Leonardo da Vinci, Compiled and Edited from the Original Manuscripts by Jean Paul Richter: Commentary*. Berkeley: University of California Press, 1977, I: 3 – 47, and passim. This account of the genealogy of the early manuscript copies is the standard source, but it is outdated, insofar as the transmission of manuscript copies cannot be reduced to a linear sequence. Several essays in *Re-Reading Leonardo* 2009 (by Williams, Farago, Cole, Bell) suggest what direction investigations of the transmission of manuscripts should take.


This first attempt to chart the widespread dissemination of the Treatise in Europe, through twenty-one case studies and a wealth of specialized bibliography, is currently the best source for the bibliography on the first printed edition (see especially the essays by Bell, Soussloff, Kemp, Barone, and Robison).

  A greatly amplified and corrected history of the printed editions of the Treatise on Painting presented in both chronological and tabular form, including reprints and noting ghost editions. It supersedes Steinitz (1958) in this respect.

**Additional Resources, specific to Science and Technology (not required but useful)**

Resources in this section examine Leonardo’s means of studying, representing, and governing nature. His involvement with this process began with his understanding of mechanics and the science of weights, pictorial perspective and formal optics, and the ways in which geometrical principles explain natural movement and force. He applied these principles in his paintings, and they are the foundation of his approaches to the physical sciences, engineering, and technology. Even before working extensively with Euclidean geometry in the early 1490s, he planned treatises on anatomy, human proportions and movement.

**Perspective, Optics, and Painting**

These studies address the roles of geometrically-based formal optics and empirical perspective in painting. Within the broader context of the natural sciences, Leonardo understood perspective as a form of motion on the model of mechanics, governed by the fundamental geometric principle that objects diminish proportionally in size as they recede proportionally into the distance. Fehrenbach 1997 examines the relationship between Leonardo’s investigations of motion in two media, water and light, a study for which Gombrich 1969 laid important groundwork. Kemp is the best source for an introduction to Leonardo’s studies of optics and pictorial perspective in its historical context, while Pedretti 1977 and Veltman 1986 locate passages in Leonardo’s fragmentary notes spanning three decades. Pedretti’s introductions are invaluable for orienting the reader to the range and development of Leonardo’s ideas. Veltman should be used with caution because he decontextualizes the statements from their organic context in the artist’s notes. Weil-Garris Brandt’s 1974 thesis about Leonardo’s revolutionary methods of composition has been influential beyond those interested in Leonardo’s scientific investigations. Luperini 2008 is an excellent resource for comparing Leonardo’s drawings of optics.

  A dissertation on the interrelationship of optics and the dynamics of water in Leonardo’s thought that presents a thesis about the internal tensions structuring his investigations in two fields united by his understanding of the mechanical laws of motion, with a good consolidated bibliography of specialized studies.

  This is a classic study that opened up the field by arguing for the underlying unity of Leonardo’s investigations of the dynamics of movement in various media. It is reprinted in: Gombrich, Ernst. The Heritage of Apelles. Studies in the Art of the Renaissance, 3. Oxford: Phaidon, 1976, pp. 39-56.

This is the most accessible, yet complex account of Leonardo’s studies of light, shade, and color set into the historical context of artistic practices. David Lindberg. *Theories of Vision from Alkindi to Kepler*, Chicago: University of Chicago Press, 1976, 154 – 68, still an excellent introduction to Leonardo’s understanding of formal optics in historical context by a preeminent historian of science.

  This catalogue in Italian and English of the Optics Room at the Museo Leonardiano in Vinci is an unusually thorough assessment of his drawings on optics.

  Pedretti discusses Leonardo’s writings on perspective, optics and painting in chronological and thematic terms that orient the reader to a wealth of information in the original manuscripts.

  The most thorough culing of passages on perspective from the original manuscripts, this resource should be used with caution because it decontextualizes Leonardo’s statements from their immediate surroundings in his notebooks spanning thirty years of activity and intellectual development.

  Noteworthy for its discussion of Leonardo’s “dark manner” and its influence on Raphael, this short book also addresses luministic imagery in general and Leonardo’s influence on Florentine mannerists. She argues that in the unfinished *Adoration of the Magi*, 1481, Leonardo arrived at a fundamentally new way of organizing the picture through tonal contrast.

### Anatomy and the Human Body

Essential references on anatomical drawings in this section include those by O’Malley and Saunders 1952, Esche 1954, Keele 1983, Clayton and Philo 2010, and Laurenza 2009. The context of the medical profession at the time of Leonardo’s anatomical work is discussed by Azzolini 2001 and Laurenza 2009, whereas the role of physiological studies within the broader context is studied by Kwakkelstein 1994. Regarding human proportions from an architect’s point of view, see the edited volume by Perissa Torrini 2009 on the *Vitruvian Man*.


  An essential resource on Anatomical Manuscript A, an inexpensive alternative to *Corpus of Anatomical Studies*. See also their *Leonardo da Vinci: The Anatomy of Man: Drawings from the Collection of Her Majesty Queen Elizabeth II*. Exh. cat., Houston: Houston MFA, 1992; and Jane

- Esche, Sigrid. *Leonardo da Vinci: Das Anatomische Werk*. Basel: Holbein Verlag, 1954. This is a comprehensive resource with a detailed and thorough commentary and catalogue on the anatomical drawings, and additional information about their context in the history of medical illustration. It is a useful companion to the O’Malley and Saunders *Leonardo... on the Human Body*.


**Arithmetic, Geometry, Physical Sciences, Engineering, and Technology**

Leonardo practiced as a consulting engineer, above all for water works like canals and for military projects and urban planning. Known then as the mechanical arts or productive sciences, these are subjects that mix the theoretical with practical experience. Leonardo excelled in these activities now considered far outside the range of an artist’s expertise. Due to the broad range of Leonardo’s activities covered in this section, it is subdivided
into overviews, and studies on physical science, engineering, and technology to aid the modern reader. This selective group includes the most useful and noteworthy studies that are among the earliest academic approaches to the origins, validity, and contexts of Leonardo’s quantitative, systematic, technical, and nature studies.

A. Overviews

The studies in this subsection are arranged chronologically in order of publication date to show how the scientific understanding of Leonardo’s fragmentary literary corpus developed. Venturi 1797 is the earliest attempt to study Leonardo’s methodology, an approach followed by Baroni et al. 1939. Duhem 1906-13 was a remarkable contribution for setting Leonardo’s ideas into their historical context, a project continued by Hart 1925, still an excellent source for the mechanical studies, and Reti 1974, the first major anthology to discuss the then recently rediscovered Madrid Codices, published in facsimile in 1974. Marinoni 1982 is the only academic monograph on Leonardo’s approaches to mathematics and geometry with a chronological discussion of specific references in his notebooks.

  
  This is the earliest publication of Leonardo’s writings on a subject other than painting. It deals primarily with hydraulics excerpted from a manuscript similar to the Codex Leicester. The essay is reprinted in: Giambattista De Toni, *Venturi e la sua opera vinciana: scritti inediti e l’Essai.* Rome: Maglione e Strini, 1924.

  
  This is the first substantial study to show Leonardo’s debts to previous and contemporary natural philosophers and engineers, establishing the major trend of Leonardo studies ever since.

  
  Containing the first English translation of Leonardo’s treatise on the flight of birds, this resource also offers the first thorough assessment, in English, of Leonardo’s studies of flight, mechanics, natural science, and contemporary and antique influences on him. Hart provided substantial revisions within a new introduction in 1961, published posthumously in the second edition of 1963.

  
  Chapters in this anthology (revised in 1956 and 1980) that offer good overviews of Leonardo’s holistic engagement with the physical sciences include Arturo Uccelli’s ‘Science of Structure,’ Carlo Zammattio’s ‘Haudraulic and Nautical Engineering,’ Roberto Marcolongo’s Da Vinci’s Mechanics,’ and Giovanni Canestrini’s ‘Leonardo’s Machines.’

  
  This volume includes – along with the discussions on Leonardo’s art and writings – chapters on the elements of machines by Ladislao Reti, the mechanics of water and stone by Carlo Zammattio, on machines and weaponry by Bern Dibner, on horology by Silvio Bedini and Ladislao Reti, and on military architecture by Ludwig Heydenreich.

Not a full inventory of approaches, nor is it thoroughly annotated, but this is the most comprehensive reference to Leonardo’s studies of geometry and mathematics in his manuscripts. For a very good overview, see: Giorgio T. Bagni and Bruno D’Amore. Leonardo e la Matematica, Florence: Giunti, 2006, which offers a good summary of the primary mathematical and geometrical problems Leonardo considered.

B. Physical Sciences
This section cites the leading works on a variety of subjects: Emboden 1987 on plants; Ligabue 1977 on fossils; Macagno 1986-2006 on fluid mechanics and Michelena- Santos 1997 on water dynamics; Starnazzi 2008 primarily on geological information, including the sites that Leonardo depicted.


- Ligabue, Giancarlo. Leonardo da Vinci e i Fossili. Vicenza: Neri Pozza, 1977. The only monograph on Leonardo’s approach to fossils, this is also the most comprehensive approach, with assessments of Leonardo’s astute observations particularly in Codices Leicester, Madrid II, and Manuscript F. Ligabue offers transcriptions of these sources, discussions on the history of fossil collecting, notes on Leonardo’s library, among other discussions.


- Starnazzi, Carlo. Leonardo: From Tuscany to the Loire. Perugia: Cartei & Bianchi, 2008. Known for identifying the location of the Arezzo landscape in the background of the Mona Lisa, in 1992, Starnazzi produced a large number of publications between 1995 and 2008 on the locations and objects depicted in Leonardo’s paintings and drawings. His work is also noteworthy for explanations of Leonardo’s resourcefulness with geological, cartographical and other technical information.

C. Engineering
Studies of Leonardo’s knowledge of engineering practices form a distinct subfield. Marinoni 1982 contributed one of the first specialized studies, while Cianchi 1984 provides a good introduction. Marani 1984 is the essential resource on Leonardo’s designs for military purposes, while Galluzzi 1987 and 1996–99, provide an excellent overview, including Leonardo’s architectural studies. Laurenza et al. 2005 provides an academic presentation of 3-D computer models.

This is one of the first books devoted only to Leonardo’s military engineering studies, well-illustrated with a commentary and notes on eighty drawings, though without references to secondary sources.


A classic and useful summary of a wide range of Leonardo’s interests in machines, with basic explanations for a general audience. Various editions are available in English and Italian.


This is an essential resource on Leonardo’s military engineering, along with the contributions of Marani and others for the Biblioteca Ambrosiana *Codex Atlanticus* exhibition series begun in 2009: *Disegni di Leonardo dal Codice Atlantic*. Exh. cats. Milan: DeAgostini, 2009-2015.


The catalogue includes substantial essays by ten leading scholars on Leonardo’s work as engineer and architect. Carlo Pedretti introduces the study, divided into two sections on engineering and architecture. In the first section, Paolo Galluzzi, Augusto Marinoni, Martin Kemp, Gustina Scaglia, and Salvatore Di Pasquale provide essays. André Chastel, Jean Guillaume, Luigi Firpo, and Pietro Marani provide essays on architecture.


An exceptional study of works by Renaissance artist/engineers, this exhibition included drawings, manuscript facsimiles, and models of engineering projects, comparing the work of Sienese engineers, Brunelleschi’s engineering, and Leonardo’s machines and mechanisms. This was one of several traveling exhibitions curated by Paolo Galluzzi in the 1990s, including: *Avant Léonard: La Science des Machines A Sienne a La Renaissance*, Avignon: Laffont, 1992.


Written by Laurenza, with three-dimensional computer illustrations by Taddei and Zanon, this is a groundbreaking combination of computer models and academic commentary. Additional discussion of these machines is in the exhibition catalogue: Lisa, Massimiliano, Mario Taddei and Edoardo Zanon. *Da Vinci’s Workshop in the Ideal City: Codices, Machines and Drawings*. In Italian and English. Exh cat. Milan: Leonardo3, 2009.

**D. Technology**

Continuing the study of Leonardo’s machines, this section cites scholarship focused on the artist’s technological expertise. Hollister-Short and Nanni 2007 and Moon 2007 are vanguard studies in considering Leonardo’s contribution to later mechanical engineering. Landrus 2010 identifies Leonardo’s innovative approaches to technical problems through a close study of his giant crossbow drawing. Ponting 1979 considers Leonardo’s drawings for textile machines; while Rosheim 2006 and Taglialagamba 2010 study his automaton drawings, the latter through computer modeling, as does Zanon 2009 for Leonardo’s studies of flight in a well-illustrated book written for a general audience.

Three essays by Hollister-Short, introduced by Nanni, address the possible influence of Leonardo’s mechanical studies on later mechanical engineers, tracing innovations in his mechanical illustrations to similar approaches in illustrations by Peter Morris (1582), Girard Desargues (1640), Johan Bartels (1711), Thomas Barney (1712), and others.

  
  The result of extensive research on the history of mechanical engineering, design and drafting methods, this study corrects previous assumptions about his lack of technical knowledge as an engineer. Innovative strategies and precision of the drawing locate the giant crossbow drawing among his plans for a military treatise, c. 1490-93, and associate it with similar working methods across other disciplines.

  
  As noted in the Exhibition Catalogues section, catalogues in this series are among the most recent studies to address Leonardo’s approaches to technology.

  
  Tracing similarities between Leonardo’s mechanical studies and those of Franz Reuleaux, Moon offers the most comprehensive assessment of Leonardo’s possible influence on the nineteenth century German ‘father of kinematics.’ He provides detailed research on the evolution of machine design methodology, along with comparisons of some of the 230 kinematic models of Reuleaux at Cornell University.

  
  Mainly a catalogue of fifty-five grayscale illustrations of structures useful for textile machines, with explanatory entries, this is an important contribution to studies of the history of technology, including Ponting’s short essay on “the technical development of the industry,” a helpful glossary, and bibliography.

  
  Addressing primarily the designs and capabilities of Leonardo’s programmable automation and lion illustrations, his mechanical knight studies, and bell ringer water clock drawings, Rosheim demonstrates how these objects could have worked. See also the exceptional 2004 exhibition on “L’automobile di Leonardo da Vinci” at the Museo Galileo website: [http://brunelleschi.imss.fi.it/automobile/].

  
  Written by Taglialegamba, with technical research and mechanical computer reconstructions by Niccolai, this is an interesting study of the history of automata, and automata designs considered by Leonardo, such as those for a mechanical lion, drums, birds and a dragonfly.

Without much reference to previous academic discussions of Leonardo’s studies of flight, this richly illustrated volume is the most extensive individual analysis of Leonardo’s notes on flight and flying machines. The book includes three-dimensional computer reconstructions throughout, along with a transcription and translation of the Codex, and a short history of flying machines from Veranzio to the Wright brothers.

Exhibition Catalogues

  To accompany the exhibition catalogue, *Mostra di Leonardo da Vinci*, these two substantial volumes provide commentary and notes, respectively, for the first blockbuster Leonardo exhibition, written by thirty-eight scholars on a wide range of topics. Portions of the commentary volume were not superseded for decades. Available in Italian, French, English and German, it was reprinted several times between 1952 and 1980.

  Groundbreaking for its integration of Leonardo’s approach as artist, natural philosopher, and engineer, this exhibition uses the same kind of innovatory approach as Kemp’s *Leonardo da Vinci: The Marvellous Works of Nature and Man*, of 1981. Much of the exhibition was in the form of drawings from the Windsor Royal Library.

  The most extensive exhibition of the full range of Leonardo’s drawings, this is also an essential reference on the available research on Leonardo in general. Most of the catalogue is by Bambach, who also contributes two essays, a documented chronology, and bibliography. Eight other scholars provide essays and thoroughly researched entries.

  Involving an extensive selection of research on a wide range of Leonardo’s work, this thorough and well-organized catalogue with entries by twenty scholars offers a multidisciplinary reconstruction of his way of thinking. Other recent multi-disciplinary exhibitions include Otto Letze and Thomas Buchsteiner, eds. *Leonardo da Vinci: Scientist, Inventor, Artist*. Exh cat. Tübingen: Institut für Kulturaustausch, 199, noteworthy for its inclusion of Leonardo’s circle and followers.

  The range of Leonardo’s investigative and inventive approaches are offered in a focused set of four groups: Leonardo’s modeling, modeling Leonardo, form and space, force and motion, understood as part of a unified theory and methodology about the acts of learning and of making things. The exhibition included six computer animated LCD projections of drawings, and large reconstructions of Leonardo’s designs.

Starting in 2009, each catalogue in this series has interpreted forty-four different drawings of the *Codex Atlanticus* for exhibitions at the Biblioteca Ambrosiana, for a total of forty-one planned exhibitions by 2015.

**Additional Resources, specific to Art and Science (Part I, general reference)**


**Additional Resources, specific to Art and Science (Part II, specific problems)**

• S. Edgerton Jr., *The Renaissance Rediscovery of Linear Perspective*, New York, 1975. (NC748.E33)