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(*b*. Metz, France, 1 July 1788; *d*. Paris, France, 22 December 1867)

geometry, theory of machines, industrial mechanics.

Poncelet was the natural son (later legitimated) of Claude Poncelet, a rich landowner and advocate at the Parlement of Metz, and Anne-Marie Perrein. At a very early age Poncelet was entrusted to a family of the little city of Saint-Avold, and they saw to his earliest education. In 1804 he returned to Metz. After brief and highly successful studies at the city's *lycée*, he entered the École Polytechnique in October 1807, but fell behind a year on account of poor health. During his three years at the Polytechnique, his teachers included Monge, S.F. Lacroix, Ampère, Poinsot, and Hachette.

In September 1810 Poncelet was admitted to the corps of military engineers. Upon graduating from the École d'Application of Metz in February 1812, he was assigned to work on fortification on the Dutch island of Walcheren. Beginning in June 1812 he participated in the Russian campaign as a lieutenant attached to the engineering general staff. In the course of the subsequent retreat, on 18 November 1812, he was taken prisoner at the Battle of Krasonï and brought to a camp on the Volga River at Saratov where he was held until June 1814. He profited from his enforced leisure by resuming his study of mathematics. Since he had no books at his disposal he was obliged to reconstruct the elements of pure and analytic geometry before undertaking the original research on the projective properties of conics and systems of conics that established the basis for his later important work in this domain. The notes from this period, which he later designated by the name "cahiers de Saratov," were published in 1862 in volume I of his *Applications d'analyse et de géométrie*.

Upon his return to France in September 1814, he was appointed captain in the engineering corps at Metz, where until May 1824 he worked on various projects in topography and fortification, and also on the organization of an engineering arsenal. Consequently, he was able to acquire a firm knowledge of the problems of fortification and industrial mechanics. Among the innovations to his credit is the development, in 1820, of a new model of the variable counterweight drawbridge, the description of which he published in 1822. His position as a military engineer left him sufficient time to pursue the research on projective geometry that he had commenced in Saratov.

After several preliminary works, which were not published until 1864 (in *Applications d'analyse et de géométrie* II), Poncelet published several articles in Gergonne's *Annales de mathématiques pures et appliquées* (starting in 1817). On 1 May 1820 he presented to the Académie des Sciences an important "Essai sur les propriétés projectives des sections coniques," which contained the essence of the new ideas he wished to introduce into geometry. The original version of this fundamental memoir also was not published until 1864 (in *Applicationsd'analyse* . . . II). Poncelet sought to show—taking the example of the conics—that the language and concepts of geometry could be generalized by the systematic employment of elements at infinity and of imaginary elements. This goal was within reach, he contended, thanks to the introduction of the concept of "ideal chord" and the use of the method of central projections and of an extension procedure called the "principle of continuity." Here Poncelet made explicit some of the ideas and methods underlying Monge's work. Thus in this remarkable paper, the fruit of investigations begun in 1813, Poncelet resolutely opened the way to the development of the subject of complex projective geometry. Cauchy, the Academy's referee, was little disposed to accept Poncelet's high estimation of the value of geometric methods. Cauchy criticized one of the paper's fundamental components, the principle of continuity, characterizing it as a "bold induction," "capable of leading to manifest errors" (report of 5 June 1820).

Poncelet was deeply affected by this serious criticism for in effect it made the principle of extension, which he considered to be an axiom, dependent on algebraic identities. Rejecting this recourse to analysis, he intransigently maintained his position against Cauchy, despite the latter's great authority. Next he reworked his 1820 "Essai" in order to make it the first section of a large *Traité des propriétés projectives des figures* (Metz-Paris, 1822). This work (discussed below) contained many extremely important innovations, ideas, methods, and original results, and it played a decisive role in the development of projective geometry in the nineteenth century.

Pursuing his geometric studies along with his professional duties, Poncelet then undertook the preparation of four important memoirs. The first two (on centers of harmonic means and on the theory of reciprocal polars) were presented to the Academy in March 1824, but the other two memoirs remained unfinished for several years following an important change in Poncelet's career.

On 1 May 1824, after long hesitation, Poncelet agreed, at the urging of Arago, to become professor of "mechanics applied to machines" at the École d'Application de l'Artillerie et du Genie at Metz. In preparing the courses he was scheduled to give

starting in January 1825, Poncelet soon displayed an increasingly lively interest in the study of the new discipline he was to teach and in various aspects of applied mechanics. As a result he interrupted the elaboration of his geometric work, returning to it only occasionally to defend certain of his ideas or to complete unfinished papers.

In 1828 Poncelet published in Crelle's *Journal für die reine und angewandte Mathematik* his first memoir of 1824, on the centers of harmonic means. A second 1824 memoir, on the theory of reciprocal polars, was not published until the beginning of 1829 in Crelle's *Journal*, because Cauchy had delayed his report on it until February 1828. On account of the long delay in publication, Poncelet had the misfortune of seeing certain of his ideas and a portion of his results attributed to other authors. Thus various articles appearing in 1826 and 1827 in Gergonne's *Annales de mathématiques* and Férussac's *Bulletin des sciences mathématiques* accorded priority to Gergonne and Plücker concerning the principle of duality and its chief applications, conceding merely vague anticipations to Poncelet. In December 1826 the latter vigorously protested to Gergonne and sent him an analysis of his memoir, which was published in March 1827 in the *Annales* accompanied by Gergonne's critical remarks. A regrettable priority dispute began; it lasted until May 1829 and opposed Poncelet first to Gergonne and then to Plücker. This distressing affair greatly upset Poncelet, who was already very hurt by Cauchy's criticisms and by the unenthusiastic welcome given his work by a group of the mathematicians at the Académie des Sciences.

Accordingly, Poncelet abandoned to his rivals the task of continuing the important work he had accomplished in projective geometry. He confined himself to completing, in the winter of 1830–1831, the two memoirs left unfinished since 1824. Even so, he published only the first memoir in the winter of 1832; in it he took up the application of the theory of transversals to curves and geometric surfaces. The second memoir he withheld until 1866, when it was included in volume II of the second edition of the *Trailé des propriétés projectives des figures*.

Beginning in 1824 Poncelet had essentially shifted his attention from geometry to applied mechanics. Although he had previously studied certain machines and ways of improving them, it was during the summer of 1824 that he achieved his first important innovation: the design and realization of an undershot waterwheel with curved paddles, which possessed a much increased efficiency. The paper he wrote on this subject gained him a prize in mechanics from the Académie des Sciences in 1825. After new trials conducted on full-scale models, he presented a revised version of his study in 1827. Yet, most of his activity at this period was devoted to elaborating and continually updating the course in mechanics applied to machines that he gave from 1825 to 1834. In addition, he prepared a parallel course in industrial mechanics on a more elementary level which he gave to artisans and workers of Metz from November 1827 to March 1830.

In preparing these courses Poncelet drew on many earlier works concerning the theory of machines and the various branches of mechanics: theoretical, experimental, and applied. In addition, he kept himself informed about all the innovations in these fields. He also profited from his practical professional experience, which he rounded out during a trip taken in 1825 for the purpose of studying the machines in the principal factories of France, Belgium, and Germany.

Poncelet's course on mechanics applied to machines was lithographed for the students at Metz. Three main versions of the work were prepared under his personal supervision: the first (partial), in 1826; the second, in 1832, with the assistance of A. T. Morin; the third (definitive), in 1836. But many other editions, both lithographed and printed, were produced without his knowledge, thus giving his work a broad distribution. The first authentic printed edition, brought out by his disciple X. Kretz, reproduced—with some notes added to bring the work up to date—the text of the lithographed version of 1836 (*Cours de mécanique appliquée aux machines* [Paris, 1874–1876]).

As for the course on industrial mechanics, a first draft, written up by F. T. Gosselin, was lithographed in three parts between 1828 and 1830. Poncelet himself wrote up a more complete version of the first part, dealing with fundamental principles and applications; it was printed in 1829 and rapidly sold out. The following year the work was reprinted as the opening section of a general treatise. The printing of the latter, interrupted on four occasions, dragged on until 1841, when it finally appeared as *Introduction à la mécanique industrielle, physique ou expérimentale*, with the peculiar feature of containing successive passages printed at different dates. In addition to numerous pirated editions, this work was brought out in a third edition by Kretz in 1870.

All this writing and correcting obliged Poncelet to rethink the presentation of the principles of mechanics with a view to applying the theoretical results to the various machines employed in industry. His chief goal was to understand and to explain the functioning of real machines in order to attempt to improve them and to increase their efficiency. For him theory was only a tool in the service of practice. Along with this sort of work, Poncelet carried out several series of experiments on the laws of the discharge of water from large orifices (in 1827 and 1828, with J.-A. Lesbros) and on the formation of ripples on the surface of water (1829); the results were published a short time later.

In 1830 Poncelet became a member of the municipal council of Metz and secretary of the Conseil general of the Moselle. Hence, it appears that he wished to remain permanently in his native city. In 1834 his nomination as scientific *rapporteur* for the Committee of Fortifications and as editor of the *Mémorial de l'officier du génie*, together with his election to the mechanics section of the Académie des Sciences, led him to move to Paris. He seems then to have forgotten his initial vocation for geometry, to which he made no more than brief references, in 1843 and in 1857. Contrariwise, he drew extensively on his technical knowledge in the memoirs he wrote for the *Mémorial* and in the reports he prepared at the request of the Académie des Sciences and of various official commissions.

Meanwhile he appears to have wanted to do more teaching, and at the end of 1837 he happily agreed to create a course on physical and experimental mechanics at the Faculty of Sciences of Paris. His assignment was of a different kind from what he had at Metz, and he sought to develop for his students a concrete conception of mechanics, midway between abstract theory and industrial application. Although his courses, which he gave until April 1848, were not published, they provided the inspiration, in part, for several books, including the last part of his *Introduction à la mécanique industrielle, physique ou expérimentale* (Metz—Paris, 1841) and H. Résal's *Éléments de mécanique* (Paris, 1851). In this manner a new current was introduced into the teaching of mechanics in France, which until then had an exclusively theoretical orientation.

In 1842 Poncelet married Louise Palmyre Gaudin. By this date he was no longer conducting truly original research. Dividing his time between teaching at the Sorbonne, his duties as an academician and military officer, and technical investigations for *Mémorial de l'officier du génie*, he waited for 1848, when he could retire as a colonel in the engineering corps.

But the Revolution of February 1848 abruptly changed this rather calm existence. Following his successive nominations as member of a commission for curriculum reform and then as professor of mechanics at an ephemeral school of administration created under the control of the Collège de France, he gave up his chair of physical and experimental mechanics at the Faculty of Sciences (16 April). A few days later he was entrusted with new responsibilities that soon monopolized his time. Having been elected to the Constituent Assembly at the end of April as deputy of the Moselle, he regularly participated as a moderate republican in the work of that body during its brief existence. At the same time, Arago, the new minister of war, appointed him brigadier general and then designated him for the post of commandant of the École Polytechnique, which he filled until October 1850. Entrusting the responsibility for current administration to his assistant, Poncelet devoted himself mainly to projects for reforming the school's curriculum. He also had to intervene directly to contain and to direct the activity of the school's students during the riots of May and June 1848.

Having retired at the end of October 1850, Poncelet gladly accepted the chairmanship of the division of industrial machines and tools at the Universal Expositions of London (1851) and Paris (1855). Profoundly interested int the rapid progress of mechanization, he transformed the simple report he was supposed to make on the London Exposition into a vast inquiry into the advances made since the beginning of the century in the conception and use of the different types of machines and tools employed in industry (textile and others). This work, to which he devoted nearly seven years, was published in 1857 in two large volumes that constitute a precious documentary source.

Several years later Poncelet undertook to regroup and edit the whole of his published and unpublished work. Of this ambitious project he was able to bring out only the four volumes of his writings on geometry, the two volumes of the *Applications d'analyse et de géométrie* (1862–1864), and the two volumes of the second edition of the *Traité des propriétés projectives des figures* (1865–1866). Certainly this was not a disinterested enterprise; the polemical character of the commentaries and introductions is obvious. Nevertheless, the compilation of these texts—to which were added a number of commentaries and notes intended to bring them up to date—does allow us to follow closely the evolution of Poncelet's thought, especially since the presentation is chronological: the unpublished notebooks from Saratov (1813–1814) in volume I of the *Applications;* published and unpublished geometric works of the period from 1815 to 1821 in volume II; republication of the original version of the *Traité des propriétés projectives des figures* (1822) in volume I of the *Traité;* and geometric works of the period 1823 to 1831 (including the writings from the polemic with Gergonne and Plücker) in volume II of the *Traité*.

Poncelet began similar work on his writings on the theory of machines and on industrial, physical, and experimental mechanics; but his death in 1867 interrupted this project. At the request of Mme Poncelet the project was resumed by Kretz, who republished the courses on industrial mechanics and on mechanics applied to machines that Poncelet had given at Metz. Kretz did not publish not publish his course on physical and experimental mechanics given at the Faculty of Sciences, despite the many documents at his disposition. Unfortunately these documents disappeared along with the bulk of Poncelet's manuscripts during World War I.

Poncelet's scientific and technical work was concentrated in two very different areas, corresponding to two successive stages in his career: projective geometry and applied mechanics. In geometry, his work, conceived for the most part between 1813 and 1824, was published between 1817 and 1832, except for some writings that appeared too late to influence the development of this field. The most significant portion of this work is the *Traité des propriétés projectives des figures*, which was the first book wholly devoted to projective geometry, a new discipline that was to experience wide success during the nineteenth century. In this domain Poncelet considered himself the successor to Desargues, Blaise Pascal, and Maclaurin and the continuator of the work of Monge and his disciples. Concerned to endow pure geometry with the generality it lacked and to assure its independence *vis-à-vis* algebraic analysis, Poncelet systematically introduced elements at infinity and imaginary elements, thus constructing the space employed in complex projective geometry. Basing his efforts on the principle of continuity and the notion of ideal chords, he also made extensive use of central projections and profitably utilized other types of transformations (homology and transformation by reciprocal polars in two or three dimensions, birational transformation, and so forth).

The distinction Poncelet made between projective and metric properties prefigured the appearances of the modern concept of structure. Among the many original results presented in the *Traité* are those stating that in complex projective space two nondegenerate conics are of the same nature and have four common points (a finding that led to the discovery of cyclic points, imaginary points at infinity common to all the cirlces of a plane), and that all quadrics possess (real or imaginary) systems of generatrices. The decisive influence that *Traité des propriétés projectives des figures* exercised on the development of

projective geometry—an influence underestimated by Chasles, Poncelet's direct rival—is brought to light by most commentators, particularly by E. Kötter, who made the most complete analysis by E. Kotter, who made the most complete analysis of it, but also by A. Schoenflies and A. Tresse, J. L. Coolidge, C. B. Boyer, N. Bourbaki, and others (see Bibliography). Of the later memoirs, the most striking is devoted to the theory of reciprocal polars, which in Poncelet's hands became an extremely fruitful instrument of discovery, although he did not perceive the more general character of the principle of duality, which was pointed out shortly afterward by Gergonne, Plücker, Möbius, and Chasles. Although it was prematurely interrupted, Poncelet's geometric work marks the first major step toward the elaboration of the fundamental theories of modern geometry.

The bulk of Poncelet's work in applied mechanics and technology was conceived between 1825 and 1840. With regard to technological innovation, his principal contributions concern hydraulic engines (such as Poncelet's waterwheel), regulators and dynamometers, and various improvements in the techniques of fortification (a new type of drawbridge, resistance of valuts, stability of revetments). In applied mechanics Poncelet made important contributions to three broad, interrelated fields: experimental mechanics. He achieved remarkable successes by virtue of his training at the École Polytechnique, his experience as a military engineer, and his vast knowledge—all of which allowed him to utilize and combine the resources of mathematics and theoretical science, the results of systematic experiments, and the teaching of industrial and craft practice.

Poncelet, whose goal was always real applications, placed experimental and practical findings above Theories and hypotheses. In the theory of machines, for example, he refused to make any theoretical classification such as Monge had, relying instead on the more concrete principles set forth by G.A. Borgnis in 1819. Instead of vast syntheses he preferred precise and limited studies, informed by a profound knowledge of the technical imperatives involved. Consequently his original work is to be found to a much greater degree in the realms of organization and improvements than in that of brilliant innovations. The influence of his thinking—a mixture of the theoretical and the concrete—on the creation of the field of applied mechanics is indicated by the success of his two lecture courses. From the two chief aspects of his work, the mathematical and the technological, it appears that Poncelet wished to contribute to the concurrent development of both pure science and its applications.

BIBLIOGRAPHY

I. Original Works. Nearly complete—although occasionally imprecise—lists of Poncelet's various publications are in I. Didion, *Mémoires de l'Académie de Metz*, **50** (1870), 149–159; and in H. Tribout, *Un grand savant; Le general Jean-Victor Poncelet* (Paris, 1936), esp. 204–220. Accessible, but much less complete, are the bibliographies in Poggendorff, **2** (1863), cols. 496–497; **3** (1898), 1057–1058; and in Royal Society *Catalogue of Scientific Papers*, IV (London, 1870), 479–481, which cites 41 articles. A partial supp. is in *Catalogue general des livres imprimés de la Bibliothéque nationale*, CXL (Paris, 1936), cols. 490–495.

As none of these bibliographies is fully satisfactory, we shall present here a selective bibliography based on the list of articles in Royal Society *Catalogue of Scientific Papers* and divided into 3 sections: geometry, other mathematical works, and applied mechanies (industrial and experimental).

Geometry. The list of the Royal Society *Catalogue of Scientific Papers*—from which the first entry, by an homonymous author, must be eliminated—contains 16 memoirs on geometry: nos. 2–9, 40 (published between 1817 and 1825), nos. 13–15 (1827–1829), nos. 18–20 (1832), and no. 31 (1843). Several works should be added to this list: "Problèmes de géométrie," in *Correspondance sur l'École polytechnique*, **2** , sec. 3 (1811), 271–274; various nn. on the projective properties of figures, on the principle of continuity, and on an instrument for tracing conics, are in *Mémoires de l'Académie de Metz*, **1–4** (Metz, 1820–1823), details of which can be found in the bibliographies of Didion and Tribout cited above; and certain items stemming from the polemic Poncelet commenced against Gergonne and Plücker: "Analyse d'un mémoire présenté à l'Académie royale des sciences," in *Annales de mathématiques pures et appliquées*, **17** , no. 9 (1827), 265–272, which is a partial text of a letter by Poncelet dated 10 December 1826; it is followed by Gergonne's "Réflexions," *ibid*., 272–276; "Note sur divers articles. . . ." in Férussac, ed., *Bulletin des sciences mathematiques*, **8** (1827), 109–117 (this note is cited as no. 13 in the list of Royal Society *Catalogue of Scientific Papers* in accord with its republication in the *Annales de mathematiques pures et appliquees*, **18,** no. 5 [1827], 125–149, with Gergonne's critical remarks and the corresponding passages from Poncelet's letter of 10 December 1826).

See also "Sur la dualité de situation et sur la theorie des polaires réciproques," *ibid*., **9** (May 1828), 292–302; "Réponse de M. Poncelet aux réclamations de M. Plücker," *ibid*., **10** (May 1829), 330–333; and "Sur la transformation des propriétés métriques des figures au moyen de la théorie des polaires réciproques," in *Comptes rendus hebdomadaires des séances de l'Académie des sciences*, **45** (1857), 553–554.

Three of Poncelet's important memoirs on geometry first became known through the critical reports on them that Cauchy presented to the Académie des Sciences. See Cauchy's reports on "Mémoire relatif aux propriétés projectives des coniques," in *Annales de mathématiques pures et appliquées*, **11** , no. 3 (1820), 69–83; on "Mémoire relatif aux propriétés des centres de moyennes harmoniques," *ibid*., **16** , no. 11 (1826), 349–360; and on "Mémoire relatif à la théorie des polaires réciproques," in *Bulletin des sciences mathématiques*, **9** (1828), 225–229.

Poncelet's geometric *oeuvre* also includes two important books. The famous *Traité des propriétés projectives des figures* (Metz—Paris, 1822), the 2nd ed. of which (2 vols., Paris, 1865–1866) reproduces the text of the 1st ed., with annotations (in vol. I) and Poncelet's geometric articles posterior to 1822 and also the principal items from his polemic with Gergonne and Plücker (1825–1829) (in vol. II).

The 2nd book is *Applications d'analyse et de géométrie . . .*, 2 vols. (Paris, 1862–1864). Its first vol. contains, with some nn. and additions, the text of the 7 notebooks in analytic and pure geometry dating from his imprisonment at Saratov (1813–June 1814); the last notebook is the first, incomplete sketch of his future treatise on projective properties. The 2nd vol. contains the text of various geometric works dating from the period 1815–1817 (notebooks 1 to 3), an unpublished memoir from 1818–1819 on the principle of continuity (no. 4), the "Essai sur les propriétés projectives des figures," presented to the Académie des Sciences on 1 May 1820 (no. 5), the text of the articles published in *Annales* between 1817 and 1822 (no. 6), and a few letters and polemical writings (no.7).

Other Mathematical Works. This relatively secondary portion of Poncelet's *oeuvre* is virtually limited to the 4 articles and memoirs cited as nos. 21–23 (1835) and no. 37 (1848) in Royal Society *Catalogue of Scientific Papers*.

Applied Mechanics (Industrial and Experimental). The Royal Society *Catalogue of Scientific Papers* mentions 20 articles from 1825 to 1852, dealing with this fundamental aspect of Poncelet's *oeuvre:* nos. 10–12, 16, 17, 24–30, 32–36, 38, 39, and 41.

To this very incomplete list should be added the reports and communications presented to the Académie de Metz between 1820 and 1834 and a portion of the reports presented to the Académie des Sciences between 1834 and 1857 (the bibliographies of Didion and Tribout cited above give references to the corresponding publications).

Eight important technical memoirs published between 1822 and 1844 are in different fascs. of the *Mémorial de l'officer du génie:* "Mémoire sur un nouveau pont-levis à contrepoids variable," no. 5 (1822); "Notice sur un pontlevis à bascule mouvante," no. 10 (1829); "Solution graphique des principales questions sur la stabilité des voutes," no. 12 (1835); "Mémoire sur la stabilité des revêtaments et de leurs fondations," no. 13 (1840); "Note additionnelle sur les relations analytiques qui tiennent entre elles la poussée et la butée des terres," *ibid*.; "Rapport et mémoire sur la construction et le prix des couvertures en zinc," *ibid*. "Observation sur le mode d'exécution et de restauration du pont-levis à contrepoids variable," *ibid*.; and "Résume historique de la question du défilement des tranchées," no. 14 (1844). See, in addition, the two short notes, "Extrait d'un mémoire sur les projets d'usines et de machines pour l'Arsenal du génie de Metz," in *Bulletin de la Société d'encouragement pour l'industrie nationale*, **23** (1824), 66–68; and "Réclamation de M. Poncelet," in *Bulletin de Férussac*, **13** (1830), 7–9.

Poncelet was also the author of two lecture courses, one on "mechanics applied to machines" and another on industrial mechanics. In addition, he wrote an important two-volume study on the different types of industrial machines and tools.

The course, *Cours de mécanique appliquée aux machines*, which grew out of lectures Poncelet had given from 1825 to 1834 to students at the École d'Application de l'Artillerie et du Génie de Metz, went through a large number of editions. The only ones among these that Poncelet himself supervised are a lithographed ed. of 1826, "Première partie du cours de mécanique appliquée aux machines . . ." a lithographed reedition, in 1832, of secs. 1 and 3 and an ed. in the same year, with the assistance of A. T. Morin, of two supplementary sets of notes: "Leçons préparatoires au lever d'usines," which became secs. 6 and 7 of the course, and "Leçons sur les ponts-levis" (sec. 8); and a lithographed reedition, in 1836, of the whole of the course (the 4th sec. now including the 5th).

These eds.—each containing original or additional material—of the course went through many other printings, certain of which were done for the use of the students at the École de Metz; other printings were done without Poncelet's knowledge. Printed eds. were also brought out without the author's authorization (e.g., *Traité de mécanique appliquée aux machines*, 2 vols. [Liège, 1845]); these contained, in addition to the 6 secs. of the lithographed edition of 1836, a brief 4th sec. on friction in gears. See also definitive posthumous ed., *Cours de mécanique appliquée aux machines*, 3rd. ed. in 2 vols. (Paris, 1874–1876).

The course, *Cours de mécanique industrielle*, stemmed from lectures Poncelet gave between 1827 and 1830 to artisans and workers of Metz. It went through several eds., which are sometimes difficult to identify.

A lithographed version, prepared with Poncelet's permission by his colleague F. T. Gosselin, was published in 3 pts. as *Cours de mécanique industrielle fait aux artistes et ouvriers messins . . .*: Première Partie: "Résumé des leçons du Cours de mécanique industrielle . . ." (Metz, 1828), of which there also exists a more detailed version; Deuxième Partie: "Cours de mécanique industrielle professé de 1828 à 1829" (Metz, 1829; 2nd ed., 1831); and Troisième Partie: "Cours de mécanique industrielle professé du mois de janvier au mois d'avril 1830."

Several other unauthorized lithographed versions of this course were also produced. Poncelet published a partial printed version of the course, *Première partie du Cours de mécanique industrielle, fait aux ouvriers messins* (Metz, 1829). An ed. of the entire course, begun in 1830 and continued in 1835, 1838, and 1839, was completed in 1841: *Introduction* à la mécanique industrielle, physique ou expérimentale, 2nd ed. (Metz-Paris, 1841), which was republished under the same title (Paris, 1870).

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Poncelet provided an analysis of his own work in geometry and applied mechanics before 1834, in *Notice analytique sur les travaux de M. Poncelet* (Paris, 1834).

Many studies have been devoted to Poncelet's geometric work. The principal studies are M. Chasles, *Aperçu historique sur le développement des méthodes en géométric . . .* (Brussels, 1837), see index; and *Rapport sur les progrès de la géométrie* (Paris, 1870), 38–45; E. B. Holst, *Om Poncelet's betydning for Geometrien* (Christiania [Oslo], 1878); E. Kötter, "Die Entwicklung der synthetischen Geometrie von Monge bis auf Staudt (1847)," in *Jahresbericht der Deutschen Mathematiker-Vereinigung*, **5** , pt. 2 (Leipzig, 1901), see index; A. Schoenflies and A. Tresse, in *Encyclopédie des sciences mathématiques*, **III** , vol. 2, fasc. 1 (Leipzig-Paris), esp. pp. 6–15; J. L. Coolidge, *A History of Geometrical Methods* (Oxford, 1940), see index; and *A History of the Conic Sections and Quadric Surfaces* (Oxford, 1945), see index; C. B. Boyer, *A History of Analytic Geometry* (New York, 1956), see index; and N. Bourbaki, *Éléments d'histoire des mathématiques*, (Paris, 1969), 165–168.

No comprehensive study has as yet been devoted to Poncelet's technical work. Its essential aspects are briefly outlined in M. Daumas, ed., *Histoire générale des techniques*, **III** (Paris, 1968), see index.

On Poncelet's work in applied mechanics, see C. Comberousse, in *Nouvelles annales de mathématiques*, 2nd ser., **13** (1874), 174–185; and an anonymous author, "J. V. Poncelet. Son rôle en mécaniquc," in *Revue scientifique*, 2nd ser., **11** (1876), 256–258.

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