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(*b*. Caen, France, 1654; *d*. Paris, France, 23 December 1722)

mathematics, mechanics.

It is due to Lagrange that Varignon's name gained recognition in the teaching of mechanics in France in the nineteenth century, and until rather recently his name was linked with a theorem on the composition of forces that is now identified with the properties of the vector product. The passage of time diminishes this kind of fame; but historians are discovering in Varignon's work– which, admittedly, is of second rank with regard to substantive results–an importance for the philosophy of science. Expressive of the attempt to reduce the number of basic principles in mechanics in order to improve the organization of the subject, Varignon's accomplishments illustrate the relationship between this effort and progress made in notation and in operational procedures in pure mathematics.

The son and brother of contracting masons, Varignon stated that his entire patrimony consisted of his family's technical knowledge; it proved, however, to be of considerable importance for his later career. He probably studied at the Jesuit *collège* in Caen, which he would have entered at a relatively late age. The only certain information about this period of his life, however, is that relating to his entrance into the religious life: he submitted to the tonsure on 19 December 1676, earned his Master of Arts degree on 15 September 1682, and became a priest in the St.–Ouen parish of Caen on 10 March 1683. An ecclesiastical career enabled him to study at the University of Caen, where he was certainly one of the oldest students.

One of Varignon's fellow students was Charles Castel, Abbé de Saint–Pierre (1658– 1743), who later achieved fame for his philanthropy. SaintPierre soon offered to share his lodgings and income with Varignon. The two left Caen for Paris in 1686. When Varignon reached Paris, he had already done considerable scientific research: and the contacts he made through Saint–Pierre accomplished the rest. As early as 1687 he had access to Pierre Bayle's periodical, *Nouvelles de la république des lettres*, for the publication of his memoir on tackle blocks for pulleys, and his first published book, *Projet d'une nouvelle méchanique*, was dedicated to the Académie des Sciences.

Although not to be compared with Newton's *Principia*, which appeared in the same year as Varignon's *Projet*, their simultaneous publication perhaps brought the latter work a greater success among French scientists than it would otherwise have had. In any case, the success of the *Projet* brought Varignon nomination as geometer in the Académie des Sciences in 1688, as well as the first appointment to the newly created professorship of mathematics at the Collége Mazarin. Within two years, therefore, Varignon was set in his career. He taugh–and resided–at the Collége Mazarin until his death. In 1704 the former secretary of the Academy, Jean-Baptiste du Hamel, resigned in Varignon's favor from the chair of Greek and Latin philosophy at the Collége Royal (now the Collége de France). The title of the chair in no way restricted the scientific topics that could be taught by its holder, who had sole discretion in this regard.

Fully occupied by his teaching duties and his responsibilities as an academician, Varignon had no leisure to prepare works for publication. After a short second work, *Nouvelles conjectures sur la pesanteur* (1690), his literary production consisted of articles for learned journals and a large number of memoirs submitted to the Academy. His correspondence, however, particularly with Leibniz and Johann I Bernoulli, bears witness to his role in the scientific life of his age. From the papers he left at his death, most of which are now lost, his disciples assembled several posthumous works: *Nouvelle mécanique* (announced in the *Project* of 1687) and *Eclaircissemens sur l'analyse des infiniment petits*, both published in 1725, and *Élémens de mathématiques* (1731), which was based on his courses at the Collège Mazarin.

Varignon's intense pedagogical activity, extending over more than thirty years, constituted his chief contribution to the progress of science and was the source of his fame. By inaugurating a chair devoted specifically to mathematics at the collège Mazarin, he joined the handful of men who were then teaching advanced mathematics; and it is in this context that his work was of great importance.

Bossut and Montucla, writing the history of mathematics half a century later, were unable to ignore Varignon; but, lacking the necessary historical distance, they were unjustly severe. Bossut, for example, wrote: "Endowed with an excellent memory, Varignon read a great deal, closely examined the writings of the pioneers *[inventeurs]*, generalized their methods, and appropriated their ideas; and some students took disguised or enlarged reformulations to be discoveries." But since the essential precondition of a teacher's effectiveness is that he constantly broaden his knowledge and keep it current, Bossut should have praised Varignon for having done just that, instead of condemning him for not sufficiently citing his sources. The latter judgment is, of course, possible; but Varignon's writings offer no incontrovertible support for it. Montucla's evaluation

was more penetrating; he criticized Varignon primarily for what may be called a mania for "generalization." Certainly, Varignon had neither a precise nor an acceptable notion of that process and often confused it with the mere use of algebraic language. Viewed in its historical context, however, this failing is not at all astonishing.

The pejorative assessments of Bossut and Montucla were echoed by Pierre Duhem, who in his *Origines de la statique* (1905–1906) wrote ironically of Varignon's naïve belief in his own originality in mechanics. Yet, like earlier criticisms, Duhem's is not wholly justified. The audacity that average intellects must needs muster in order to fight for progressive ideas always presupposes a certain naïveté on their part. Indeed, the more it becomes evident that Varignon was not a genius, the less the defects of his thought ought to be allowed to weigh against estimates of his real accomplishments.

From this point of view, Lagrange underscored the essential point. In the posthumous edition of the *Nouvelle mécanique* he found the text of a letter from Johann Bernoulli to Varignon (26 January 1717) marking the emergence of the principle of virtual velocities, and he realized that in this matter Varignon deserves credit on two counts: for preparing the way for and eliciting Bernoulli's statement, and for attempting to provide the broadest justification of the principle. Thus the period between the *Projet* of 1687 and the *Nouvelle mécanique* witnessed the development of what appeared a century later to be the very foundation of classical mechanics.

Lagrange was not mistaken, either, about Varignon's active role in the initial development of the principle of the composition of forces. The technique of composing forces by the rule of the parallelogram had undergone more than a century of development when it was published, simultaneously, in 1687 in Newton's *Principia*, Varignon's *Projet*, and the second edition of Bernard Lamy's *Traitez de méchanique*. The enunciation of the principle, which appeared as a consequence of the composition of infinitely small movements and not of finite ones, eliminated a troublesome confusion that had hampered progress in the subject.

The simultaneous publication of the principle makes difficult any judgment regarding priority. Nevertheless, it was Varignon alone who grasped two important points. The first is that the law of the lever does not hold a privileged position in statics, and that the unification of "mechanics" (the science of simple machines) was to be carried out on the basis of the composition of forces. The second concerns the inclined plane: that the real reason for the equilibrium observed is that the resultant of the applied forces is orthogonal to the possible displacement. These two points provide a good indication of Varignon's contribution to the development of the principle of virtual velocities.

It must, of course, be added that his contribution was limited to general statics; but this was the point of departure for d'Alembert's subsequent extension of the principle to dynamics. In the latter field Varignon did not solve any of the important problems of his time–as Bossut correctly observed. Nevertheless, in his memoirs to the Academy, he showed how to apply infinitesimal analysis to the science of motion and how, in specific cases, to use the relationship between force and acceleration. The laborious nature of this work does not detract from its historical importance.

In working with the model of falling bodies, Varignon encountered difficulties in obtaining acceleration as a second derivative. This problem had the advantage, however, of obliging him to reassess the importance of the new differential and integral calculus. His acceptance of the new procedures occurred between 1692 and 1695, and he was among those who gave the most favorable reception to the publication of L'Hospital's *Analyse des infiniment petits* in 1696. The *Eclaircissemens* is composed of critical notes that Varignon, as a professor, considered necessary in presenting L'Hospital's pioneering work to young mathematicians—further evidence of his constructive role in the movement to transform the operations used in mathematics. But Varignon accomplished even more: in 1700–1701 he refuted Rolle's arguments against the new calculus, challenged the cabal that had formed within the Academy, and obliged leibniz to furnish a more precise account of his ideas. Leibniz, to be sure, did not give him all the aid desired. Nevertheless, he encouraged Varignon to cease debating principles and to start developing mechanical applications of the new mathematics. The questions that Varignon subsequently treated show how faithfully he followed Leibniz' advice.

In his course at the Collège Royal for 1722–1723, Varignon planned to discuss the foundations of infinitesimal calculus but was able to do no more than outline his ideas. Although he died before he could present what was undoubtedly the core of a lifetime's experience, that experience had already borne fruit.

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