Roberval, Gilles Personne (or Personier) De | Encyclopedia.com

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(*b*. near Senlis, France, 10 August 1602;[1] *d*. Paris, France, 27 October 1675) *mathematics, mechanics, physics*.

Very little is known about Roberval's childhood and adolescence. His parents seem to have been simple farmers. He stated that lie was born and educated among the people (*inter multos*). J.-B. du Hamel reports that he devoted himself to mathematical studies beginning at the age of fourteen. Having left his family at an unknown date, Roberval traveled through various regions of the country, earning a living from private lessons and continuing to educate himself. In 1628 he arrived in Paris and put himself in touch with the scientists of the Mersenne circle: Claude Mydorge, Claude Hardy, and Étienne and Blaise Pascal. Mersenne, especially, always held Roberval in the highest esteem. In 1632 Roberval became professor of philosophy at the Collège de Maître Gervais. On 24 June 1634, he was proclaimed the winner in the triennial competition for, the Ramus chair (a position that he kept for the rest of his life) at the Collège Royal in Paris, where at the end of 1655 he also succeeded to Gassendi's chair of mathematics. In 1666 Roberval was one of the charter members of the Académie des Sciences in Paris.

Roberval's to keep his own discoveries secret has been attributed to his desire to profit from them in order to retain the Ramus chair. But this habit to priority. He himself published only two works: *Traité de méchanique* (1636) and *Aristarchi Samii de mundi systemate* (1644). A rather full collection of his treatises and letters was published in the *Divers ouvrages de mathématique et de physique par messieurs de I'Académie royale des sciences* (1693), but since few of his other writings were published in the following period, Roberval was for long eclipsed by Fermat, Pascal, and, above all, by Descartes, his irreconcilable adversary. Serious research on Roberval dates from approximately the end of the nineteenth century, and many of his writings still remain unpublished.

In the field of elementary geometry, a collection of Roberval's manuscripts includes some remarkable constructions of isoperimetric figures,[2] of which at least two are earlier than October 1636.[3] In addition, in 1644 Mersenne reported, without indicating the procedure employed, several problems solved by Roberval under the condition of the *extrema*.[4]

Roberval was one of the leading proponents of the geometry of infinitesimals, which he claimed to have taken directly from Archimedes, without having known the work of Cavalieri. Moreover, in supposing that the constituent elements of a figure possess the same dimensions as the figure itself, Roberval came closer to the integral calculus than did Cavalieri, although Roberval's reasoning in this matter was not free from imprecision. The numerous results that he obtained in this area are collected in the *Divers ouvrages*, under the title of *Traité des indivisibles*. One of the first important findings was, in modern terms, the definite integration of the rational power, which he most probably completed around 1636, although by what manner we are not certain. The other important result was the integration of the sine, and he formulated by virtue of it the problem of which he was so proud: Trace on a right cylinder, with a single motion of the compass, a surface equal to that of a given square, or, except for the bases, of an oblique cylinder. Furthermore, in 1644 Mersenne recounts —but again without saying how—that Roberval was the first to square the surface of the oblique cone. Yet the most famous of his works in this domain concerns the cycloid. Roberval introduced the "compagne" ("partner") ($x = r\theta$ $y = r{-}r\cos\theta$) of the original cycloidal curve and appears to have succeeded, before the end of 1636, in the quadrature of the latter and in the cubature of the solid that it generates in turning around its base. But the cubature of the solid of revolution around its axis (presented in the treatise *Ad trochoidem, ejusque solida*),[5] must have been achieved between May 1644 and October 1645. Roberval, moreover, knew how to extend all these results to the general case:

$$x = a\theta - b\sin\theta,\ y = a - b\cos\theta.$$

On account of his method of the "composition of Movements" Roberval may be called the founder of kinematic geometry. This procedure had three applications—the fundamental and most famous being the construction of tangents. "By means of the specific properties of the curved line," he stated, "examine the various movements made by the point which describes it at the location where you wish to draw the tangent: from all these movements compose a single one; draw the line of direction of the composed movement, and you will have the tangent of the curved line."[6]

Roberval conceived this remarkably intuitive method during his earliest research on the cycloid (before 1636). At first, he kept the invention secret, but he finally taught it between 1639 and 1644; his disciple François du Verdus recorded his lessons in *Observations sur la composition des mouvemens, et sur le moyen de trouver les touchantes des lignes courbes*.[7] Jean-Marie-Constant Duhamel's criticism of this method (1838) applied only to the abuse some others had made of the parallelogram or parallelepiped of velocities; Roberval himself employed, in his own fashion, the rule advanced by Duhamel. In the last analysis, the latter failed to recognize that Roberval's method had to do with the moving system of co-ordinates.

In the second place, he also applied this procedure to comparison of the lengths of curves, a subject almost untouched since antiquity. In the winter of 1642–1643, Roberval equated not only the spiral and the parabola in their ordinary forms, but also the curves $r = k\theta^n$ and $y^{n+1} = k'x^n$ (n being any whole number).[8] He accomplished this equation by purely kinematic considerations, probably without making any computations at all (according to an unpublished work, preserved in the archives of the Academy of Sciences). In addition, he declared that he had carried out the rectification of the simple cycloid before 1640, by reducing it kinematically to the integration of the sine—a serious claim that would deprive Torricelli of the glory of having first rectified a curve (1644 or 1645), but for which there is not yet any objective proof. It is possible, however, that Roberval discovered before August 1648 the equality in length of the generalized cycloid and the ellipse, which was established by Pascal in 1659.[9]

The third application consisted in determining extrema, and four problems of this type are solved in an unpublished manuscript.[10] The solution is certainly ingenious, but we know of no other writings by Roberval that treat more difficult problems of the same type in this fashion. It was quadrature that, in accord with the general trend of mathematics in his century, Roberval pursued as the principal goal of his kinematics: but his efforts in this direction were not fruitful. Lucking the aid of analysis, his kinematics was still far from the Newtonian method of fluxions.

Roberval composed a treatise on algebra, *De recognitione aequationum*, and another on analytic geometry, *De geometrica planarum et cubicarum aequationum resolutione*.[11] Before 1632, he had studied the "logistica speciosa" of Viète; but the first treatise, which probably preceded Descartes's *Géométrie*, contains only the rudiments of the theory of equations. On the other hand, in 1636 he had already resorted to algebra in search of a tangent. By revealing the details of such works, he would have assured himself a more prominent place in the history of analytic geometry, and even in that of differential calculus. But the second treatise cited above was written later than the *Géométrie*, and therefore contributed nothing of particular interest, except for a thorough discussion of the "ovale optique." the style of which, however, is that of elementary geometry.

Turning now to mechanics, his *Traité* of 1636 led to the law of the composition of forces through a study—like the one in the *Beghinselen der weegconst* of Stevin—of the equilibrium of a body supported at first on an inclined plane, then suspended by two cords. But when Roberval reduced the equilibrium on the inclined plane to that of the balance, he was very close to Galileo, whose *Le meccaniche* he no doubt knew through the efforts of Mersenne. This treatise of Roberval contains, however, a clear notion of the pressure that the body exerts on the plane, and of the equivalent resistance that the latter opposes to the former. Moreover, Roberval stated that the treatise "is only a sample of a greater work on Mechanics which cannot so soon make its appearance." Perhaps he meant the French version of a booklet in Latin, now lost, which he had written before 1634, and from which he had just taken this treatise on statics.

Roberval's ambition did not cease to grow. In 1647 he wrote to Torricelli: "We have constructed a mechanics which is new from its foundations to its roof, having rejected, save for a small number, the ancient stones with which it had been built."[12] Roberval indicated the materials for this work: book I, on the center of action of forces (*de centro virtutis potentiarum*) in general; book II, on the balance: book III, on the center of action of particular forces; book IV, on the cord; book V, on instruments and machines; book VI, on the forces that act within certain media; book VII. on compound movements; and book VIII, on the center of percussion of moving forces. This great treatise has not come down to us; the most we can do is to find some traces of its content among Roberval's surviving papers. The "Tractatus mechanieus, anno 1645,"[13] treating of the composition of parallel forces, might have been the beginning of book I. The "demonstratio mechaniea,"[14] establishing the law of the balance in the manner of Stevin and Galileo,[15] was undoubtedly destined for book II. Since book III was to deal with the center of gravity, the "Theorema lemmaticum"[16] would have served as its basis; this unpublished manuscript demonstrates the general equation of moments in space of three dimensions. As for book IV, the booklet mentioned above would already have furnished the material for it. The "Proposition fondamentale pour les corps flottams sur l'eau"[17] would have been included in book VI. With regard to book VII, we may refer to the preceding paragraphs on kinematic geometry. And yet around 1669, Roberval wrote *Projet d'un livre de mechanique traitant des mouvemens composez*.[18] Book VII would therefore not have been completed; Roberval dreamed, certainly with too great temerity, of a vast physical theory based uniquely on the composition of motions. Concerning book VIII, a part of it is in the unpublished manuscript "De centro percussionis,"[19] as well as three texts of 1646 in the *Oeuvres de Descartes*,[20] The problem of the center of oscillation of the compound pendulum provoked in 1646 a new polemic between Descartes and Roberval. Although Descartes had a better idea of the center of oscillation, nevertheless he was wrong in neglecting the directions of the forces. Roberval well knew how to rectify this error. But he did not consider it necessary to locate the center of oscillation on the right line linking the point of suspension and the center of gravity of the body under consideration; he doubted that, even located on this right line, the point that he determined was precisely the center of oscillation.

On 21 August 1669 Roberval presented to the Royal Academy of Sciences the plans for a particular type of balance, which today bears his name. Although the notion of virtual work is clearly contained and expressed therein under the name "momentum," he probably considered only the finite path of the weight.

In mechanics, no less than in mathematics, Roberval displayed a great concern for rigor. For example, he began the "Tractatus mechanieus, anno 1645" by postulating the possibility of the movement of a point along an arbitrary curve. It is not the case, however, that he failed to appreciate the importance of experiment in mechanics; and positivism is even more evident in his work in physics. In this regard, it is also useful to consult his philosophical reflections, such as “Les principes du debvoir et des cognoissances humaines,”[21] *L’éuidence—le chymère*,[22] and the unpublished manuscript “Quelle créance l’homme doit avoir à ses sens et à son entendement” (in Archives of the Academy of Sciences).

Roberval’s positivism appears in a particularly nuanced form in the book *De mundi systemate* of 1644, where he claimed to have translated an Arabic manuscript of Aristarchus, to which he had added his own notes, all of them favorable to the author. Yet he did not adhere to the system of Aristarchus to the exclusion of those of Ptolemy and Tycho Brahe. In the dedication of the work, Roberval wrote: “Perhaps all three of these systems are false and the true one unknown. Still, that of Aristarchus seemed to me to be the simplest and the best adapted to the laws of nature.” It is with this reservation that Roberval expressed his opinion on the great system of the world (the solar system), the minor systems (planetary), the motions of the sun and the planets, the declination of the moon, the apogees and perigees, the agitation of the oceans, the precession of the equinoxes, and the comets. Despite this reservation, Roberval appeared convinced of the existence of universal attraction, which—under the inspiration of Kepler—he put forth as the foundation of his entire astronomy: “In all this worldly matter [the fluid of which the world is composed, according to our author], and in each of its parts, resides a certain property, or accident, by tile force of which this matter contracts into a single continuous body.”[23]

On the problem of the vacuum, which had been agitating French scientific circles since 1645, Roberval composed two *Narrationes*.[24] In the first of them (dated 20 September 1647), he reported Pascal’s experiments at Rouen and the experiments he himself subsequently had undertaken. Roberval agreed with his friend, concluding that if the space at the top of the barometric tube was not absolutely empty, it was free of all the elements alleged by the philosophers. But the second *Narratio*—probably composed in May-June and October 1648—is much more important. In this work Roberval proved himself to be a very skillful and scrupulous experimenter. He explained the suspension of the mercury in the tube by the pressure of the air on the exterior mercury. Moreover, a very ingenious apparatus that he had invented to support this thesis later served as the prototype for the one in Pascal’s experiment of “the vacuum in the vacuum,” described in the *Traité de 1’équilibre des liqueurs et de la pesanteur de la masse de l’air*. Roberval thus remained in agreement with his friend, save that he attributed the equilibrium of the liquids to the universal attraction mentioned in the discussion of his astronomical work. But, on the other hand, he did deliberately assert the existence of rarefied air in the top of the tube. He showed in particular that an exhausted carp bladder placed in the empty space of the tube became inflated by virtue of the spontaneous dilation of the air. And that, in principle, is all he wished to do. He refrained from tackling the ancient question of whether a vacuum existed in nature. While ironically returning the problem to the schools, he did not at all tolerate the Cartesian confusion of space and matter.

The same positivism is evident in book II of *L’optique et la catoptrique de Mersenne* (1651), in which proposition 4 is particularly remarkable for its disdainful rejection of all speculation on the nature of light. Roberval promised himself to “join experiment to reasoning” in the study of the phenomenon of reflection. In the sane spirit, he rewrote the “Livre troisiesme de la dioptrique, ou des lunettes,”[25] where we find again his cherished geometric dissertation on the oval.

NOTES

1. According to Pierre Desnoyers, secretary to the queen of Poland and correspondent of Roberval.

2. Bibliothèque Nationale, fonds latin, nouvelle acquisition 2340, 1_r-6_v, 196_r-214_r.

3. Given two cones of unequal bases or heights of two cones of equal volume and surface area (the bases included or excluded), find the cones. *See Oeuvres de Fermat*, 11, 82–83.

4. M. Mersenne, “Phaenomena hydraulica,” in Cogitata *physico-mathematica*, 55–77.

5.*Divers ouvrages*, 257–274.

6.*Ibid*., 80.

7.*Ibid*., 69–111.

8. One determines k, k' in such a manner that the two curves will have equal subtangents for any given pair of equal values of r and y.

9. The arc corresponding to the interval $[\theta_1, \theta_2]$ of the generalized cycloid (see end of fourth paragraph) is double the arc corresponding to the interval $[\theta_1/2, \theta_2/2]$ of the ellipse $x = (a + b) \cos \theta$, $y = (a - b) \sin \theta$.

10. Bibliothèque Nationale, fds. fr. 9119, 464_v-470_r.

11.*Divers outrages*, 114–189.

12. The original is in Latin, in *Divers outrages*, 301.

13. Bibliothèque Nationale, fds. lat. 7226, 2r-27r.

14.*Ibid*., 31r-33v.

15.*The Principal Works of Simon Stevin*, I (Amsterdam, 1955), 116–125; *Le opere di Galileo Galilei*, VIII, 152–153.

16. Bibliothèque Nationale, fds. lat. 7226, 59_r-82_r.

17.*Ibid*., 207_v-210_r.

18.*Divers ouvrages*, 112–113.

19. Bibliothèque Nationale, fds. lat. nouv. acq. 2341, 41r-45r.

20.*Ocuvres de Descartes*, IV, 420–428, 502–508.

21. In Victor Cousin, *Fragments de philosophic cartésienne*, 242–261.

22.*Oeuvres de Blaise Pascal*, 11, 49–51.

23.*Op. cit*., 2–3.

24.*Oeuvres de Blaise Pascal*, II, 21–35, 310–340.

25. Bibliothèque Nationale, fds. fr. 12279. Ir-108r.

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I. Original Works. Works published during Roberval's lifetime include *Traité de mechanique. Des poids soustenus par des puissances sur les plans inclinez à l'horizon. Des puissances qui soustiennent un poids suspendu à deux chordes* (Paris, 1636), repr. in Mersenne, *Harmonie universelle* (see below); and *Aristarchi Samii de mundi systemate, partibus et motibus ejusdem libellus. Adjectae sunt AE. de Roberval … notae in eundem libellum* (Paris, 1644), repr. with some modifications in Mersenne, *Novarum observationum …* (see below). The extract of a letter to Mersenne and of another to Torricelli is in Dati (see below), pp. 8, 12–14. Two anti-Cartesian letters and an annexed fragment were published by C. Clerselier in *Lettres de M. Des-Cartes*, III (Paris, 1667). 313–321, 498–505. See also *L'optique et la catoptrique du R. P. Mersenne, mise en lumière uprès la mort de l'autheur*, (Paris, 1651), of which propositions 4–16 (pp. 88–131) of bk. II are actually the work of Roberval.

Posthumous publications before the end of the nineteenth century include 4 letters to Fermat, in *Varia opera mathematica D. Pari de Fermat Senatoris Tolosani* (Toulouse, 1679), 124–130, 138–141, 152–153, 165–166; 6 treatises (one of which is completely fragmentary) and 2 letters in *Divers ouvrages de mathematique et de physique par messieurs de l'Academic rayale des sciences* (Paris, 1693), 69–302, repr. in *Mémoires de l'Académie royale des sciences; depuis 1666 jusqu'a 1699*, VI (Paris, 1730), 1–478; "Avant-propos sur les mathematiques." in Cousin (see below), 236–239; and "Les principes du debvoir et des cognoissances humaines," *Ibid*., 242–261.

Letters and other minor writlings of Roberval have been published or reprinted in the following works, in which onemay also find various information about him: Charles Henry, *Huygens et Roberval* (Leiden, 1880), 35–41; *Oeuvres de Blaise Pascal*, I-II (see below); *Oeuvres completes de Christiaan Huygens, publiées par la Société Hollandaise des Sciences*, **I** (The Hague, 1888); *Oeuvres de Fermat*, Charles Henry and Paul Tannery, eds., II, IV (Paris, 1894, 1912), with supp. by Cornelis de Waard (Paris, 1922); *Oeuvres de Descartes*, C. Adam and P. Tannery, eds., II, IV (Paris, 1898, 1901); *Opere di Evangelista Turricelli*, G. Loria and G. Vassura, eds., III (Faenza, 1919); Mersenne's *Correspondance*, C. de Waard, R. Pintard, and B. Rochet, eds., III-XII (Paris, 1946–1973) and L. Auger, *Un savant méconnu* (see below), 179–202, which presents two new documents on gravity (*pesanteur*) and on the so-called Roberval balance.

The Bibliothèque Nationale in Paris possesses numerous unpublished MSS of Roberval, cataloged as follows: funds latins 7226, 11195, 11197; fds lat. nouvelles acquisitions 2338, 2340, 2341; fds. Irançais 9119, 9120, 12279; and fds. fr. nouv. acq. 1086, 2340, 5161, 5175, 5856. The Archives of the Academie des Sciences also preserve a good number of Roberval's papers, almost all of which are unpublished and poorly classified. Besides the writings dealing with mathematics and mechanics, one may find items such as "Cours d'astronomie," "L'aere chrestienne." "Tractatus de architectura," "Geographie physique sur les golfes," "L'arpenlage," and "Du nivelage." The Bibliothèque Sainte Genevieve possesses, according to Auger. "Trois tables de la grandeur des parties d'une fortification royale, dédiées à M. le Due de Buckingham par M. Roberval, Paris. 1645."

Many of Roberval's papers preserved in the archives of the Academic des Sciences have been classified by Alan Gabbey and are described in a catalog (deposited in the archives of the Academy), which he prepared in 1966, and which covers MSS and documents by or relating to the founding members of the Academy, other than Huygens. The present author was not able to consult the catalog at the time of the composing of this article.

II. Secondary Literature. On Roberval and his work, see Léon Auger, "Les idées de Roberval sur le système du monde," in *Revue d'histoire des sciences et de leurs applications*, **10** , no. 3 (1957), 226–234, and *Un savant méconnu: G. P. de Roberval, son activité intellectuelle dans les domaines mathématique, physique, mécanique et philosophique* (Paris, 1962); Adrien Baillet, *La vie de Monsieur Des-Cartes*, 2 vols. (Paris, 1691); Le Marquis de Condorcet, "èloge de Roberval" (1773), republished in Oeuvres de Condorcet, II (Paris, 1847), 5–12; Pierre Costabel, "La controverse Descartes-Roberval an sujet du centre d'oscillation," in *Revue des sciences humaines*, n.s. **61** , fasc. 61 (Lille-Paris, 1951), 74–86; Victor Cousin, "Roberval philosophe," in *Fragments de philosophie cartèsienne* (Paris. 1845), 229–261; Carlo Dati, *Lettera a Filaleti di Timauro Antiate della vera storia della cicloide, e della famosissima esperienza dell'argento vivo* (Florence, 1663); Jean-Marie-Constant Duhamel, "Note sur la méthods des tangentes de Roberval," in *Mémoires présentés par divers savants à l'Académie des sciences de l'Institut de France*, **5** (1838), 257–266; Pierre Duhem, *Les origines de la statique*, 2 vols. (Paris, 1905–1906), and *études sur Léonard de Vinci*, **I** (Paris, 1955); MarieAntoinette Fleury and Georges Baithache, "Le testament, l'inventaire après décès … de Gassendi," in *Tricentenaire de Gassendi*, Actes du Congrès de Digne, 1955 (Paris-Digne, 1957), 21–68; Kokiti Hara, "étude sur la théorie des mouvements composés de Roberval" (*thèse de troisième cycle*, defended in 1965 at the Faculté des lettres et sciences humaines de l'Université de Paris), and "Remarque sur la quadrature de la surface du cône oblique," in *Revue d'histoire des sciences et de tears applications*, **20** , no. 4 (1967), 317–332; J. E. Hofmann and P. Costabel, "A propos d'un problème de Roberval," *Ibid*., **5** , no. 4 (1952), 312–333; Jean Hard, "Autre remarque sur la quadrature de la surface du cône oblique," *Ibid*., **20** , no. 4 (1967), 333–335; Robert Lenoble, "Roberval editeur de Mersenne et du P. Niceron," *Ibid*., **10** , no. 3 (1957), 235–254; and M. Mersenne, *Harmonie universelle*, … 2 vols. (Paris, 1636), reprinted in facsimile (Paris, 1963), *Cogitata physico-mathematica* (Paris, 1644), and *Novarum Observationum physico-mathematicarum toners III* (Paris, 1647); Blaise Pascal, *Histoire de la roulette*… (10 Oct. 1658), also in Latin, *Historia trochoidis* (sane date), republished in *Oeuvres de Blaise Pascal*, L. Brunschvicg, P. Boutroux, and F. Gazier, eds., VIII (1914), 195–223; Bernard Rochot, "Roberval, Mariotte et la logique," in *Archives internationales d'histoire des sciences*, 22 (1953), 38–43; Paul Tannery, *La correspondance de Descartes dans les inédits du fonds Libri* (Paris, 1893), republished in *Mémoires scientifiques*, 6 (1926), 153–267; Cornelis de Waard, "Une lettre inédite de Roberval du 6 janvier 1637 contenant Ie premier énoncé de la cycloïde," in *Bulletin des sciences mathématiques*, 2nd ser., 45 (1921), 206–216, 220–230; and Evelyn Walker, *A Study of the Traité des indivisibles de* G. P. *de Roberval* (New York, 1932).

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