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(*b*. Paris, France, *ca*. 1605; *d*. Paris, 17 January 1675)

mathematics, physics, astronomy.

Frenicle was an accomplished amateur mathematician and held an official position as counselor at the Cour des Monnaies in Paris. In 1666 he was appointed member of the Academy of Sciences by Louis XIV. He maintained correspondence with the most important mathematicians of his time—we find his letters in the correspondence of Descartes, Fermat, Huygens, and Mersenne. In these letters he dealt mainly with questions concerning the theory of numbers, but he was also interested in other topics. In a letter to Mersenne, written at Dover on 7 June 1634, Frenicle described an experiment determining the trajectory of bodies falling from the mast of a moving ship. By calculating the value of g from Frenicle's data we obtain a value of 22.5 ft./sec.^{2}., which is not far from Mersenne's 25.6ft./sec^2. In addition, Frenicle seems to have been the author, or one of the authors, of a series of remarks on Galileo's *Dialogue*.

On 3 January 1657 Fermat proposed to mathematicians of Europe and England two problems:

(1) Find a cube which, when increased by the sum of its aliquot parts, becomes a square; for example, $7^3 + (1 + 7 + 7^2) = 20^2$.

(2) Find a square which, when increased by the sum of its aliquot parts, becomes a cube.

In his letter of 1 August 1657 to Wallis, Digby says that Frenicle had immediately given to the conveyer of Fermat's problems four different solutions of the first problem and, the next day, six more. Frenicle gave solutions of both problems in his most important mathematical work, *Solutio duorum problematum circa numeros cubos et quadratos, quae tanquam insolubilia universis Europae mathematicis a clarissimo viro D. Fermat sunt proposita* (Paris, 1657), dedicated to Digby. Although it was assumed for a long time that the work was lost, four copies exist. In it Frenicle proposed four more problems: (3) Find a multiply perfect number x of multiplicity 5, provided that the sum of the aliquot parts (proper divisors) of $5x$ is $25x$. A multiply perfect number x of multiplicity 5 is one the sum of whose divisors, including x and 1, is $5x$. (4) Find a multiply perfect number x of multiplicity 7, provided that the sum of the aliquot divisors of $7x$ is $49x$. (5) Find a central hexagon equal to a cube. (6) Find r central hexagons, with consecutive sides, whose sum is a cube. By a central hexagon of n sides Frenicle meant the number.

Probably in the middle of February 1657 Fermat proposed a new problem to Frenicle: Find a number x which will make $(ax^2 + 1)$ a square, where a is a (nonsquare) integer. We find equations of this kind for the first time in Greek mathematics, where the Pythagoreans were led to solutions of the equations $y^2 - 2x^2 = \pm 1$ in obtaining approximations to Next the Hindus Brahmagupta and Bhaskara II gave the method for finding particular solutions of the equation $y^2 - 2x^2 = 1$ for a = 8, 61, 67, and 92. Within a very short time Frenicle found solutions of the problem. In the second part of the *Solutio* (pp. 18–30) he cited his table of solutions for all values of a up to 150 and explained his method of solution. Fermat stated in his letter to Carcavi of August 1659 that he had proved the existence of an infinitude of solutions of the equation by the method of descent. He admitted that Frenicle and Wallis had given various special solutions, although not a proof and general construction. After noting in the first part of the *Solutio* (pp. 1–17) that he had made a fruitless attempt to prove that problem (1) is unsolvable for a prime x greater than 7, Frenicle investigated solutions of the problem for values of x that are either primes or powers of primes. At the end of this part he made some remarks about solutions of the equations $\sigma(x^3) = ky^2$ and $\sigma(x^2) = ky^3$, where $\sigma(x)$ is the sum of the divisors (including 1 and x) of x.

Also in 1657 Fermat proposed to Brouncker, Wallis, and Frenicle the problem: Given a number composed of two cubes, to divide it into two other cubes. For finding solutions of this problem Frenicle used the so-called secant transformation, which can be represented as

Although Lagrange is usually considered the inventor of this transformation, it seems that Frenicle was first. Other works by Frenicle were published in the *Mémories de l'Académie royale des sciences*. In the first of these, "Méthode pour trouver la solution des problèmes par les exclusions," Frenicle says that in his opinion, arithmetic has as its object the finding of solutions in integers of indeterminate problems. He applied his method of exclusion to problems concerning rational right triangles, e.g., he discussed right triangles, the difference or sum of whose legs is given. He proceeded to study these figures in his *Traité des triangles rectangles en nombres*, in which he established some important properties. He proved, e.g., the theorem proposed by Fermat to André Jumeau, prior of Sainte-Croix, in September 1636, to Frenicle in May (?) 1640, and to Wallis on 7 April 1658: If the integers *a, b, c* represent the sides of a right triangle, then its area, $bc/2$, cannot be a square number. He also proved that no right triangle has each leg a square, and hence the area of a right triangle is never the double of a square. Frenicle's "Abrégé des combinaisons" contained essentially no new things either as to the theoretical part or in the applications. The most important of these works by Frenicle is the treatise "Des quarrez ou tables magiques." These squares, which are of Chinese origin and to which the Arabs were so partial, reached the Occident not later than the fifteenth century. Frenicle pointed out that the number of magic squares increased enormously with the order by writing down 880 magic squares of the fourth order, and gave a process for writing down magic squares of even order. In his *Problèmes plaisants et délectables* (1612), Bachet de Méziriac had given a rule "des terrasses" for those of odd order.

BIBLIOGRAPHY

I. Original Works. Copies of the *Solutio* are in the Bibliothèque Nationale, Paris: V 12134 and Vz 1136: in the library of Clermont-Ferrand: B.5568.R; and in the Preussische Staatsbibliothek, Berlin: Ob 4569. Pt. I of the *Traité des triangles rectangles en nombres* was printed at Paris in 1676 and reprinted with pt. 2 in 1677. Both pts. are in *Mémoirés de l'Académie royale des sciences*, *5* (1729), 127–208; this vol. also contains "Méthode pour trouver la solution des problèmes par les exclusions," pp. 1–86 "Abrégé des combinaisons," pp. 87–126; "Des quarrez ou tables magiques," pp. 209–302; and "Table générale des quarrez magiques de quatres côtez," pp. 303–374, which were published by the Academy of Sciences in *Divers ouvrages de mathématique et de physique* (Paris, 1693).

II. Secondary Literature. There is no biography of Frenicle. Some information on his work may be found in A.G. Debus, "Pierre Gassendi and His 'Scientific Expedition' of 1640," in *Archives internationales d'histoire des sciences*, **63** (1963), 133–134; L. E. Dickson, *History of the Theory of Numbers* (Washington, D.C., 1919–1927), II, *Passim*, C. Henry, "Recherches sur les manuscrits de Pierre de Fermat suivies de fragments inédits de Bachet et de Malebranche," in *Bullettino di bibliografia e di storia delle scienze matematiche e fisiche*, **12** (1870), 691–692; and J. E. Hofmann, "Neues uber Fermats zahlentheoretische Herausforderungen von 1657," in *Abhandlungen der Preussischen Akademie der Wissenschaften*, Math. -naturwiss. Klasse, Jahrgang 1943, no. 9 (1944); and "Zur Frühgeschichte des Vierkubenproblems," in *Archives internationales d'histoire des sciences*, **54–55** (1961), 36–63.

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