Coriolis, Gaspard Gustave De | Encyclopedia.com

(*b*. Paris, France, 21 May 1792; *d*. Paris, 17 September (1843),

theoretical and applied mechanics.

Descended from an old Provençal family of jurists ennobled in the seventeenth century, G. Coriolis (as he signed his name) was born into troubled times. He was the son of a loyalist officer of Louis XVI who had taken refuge in Nancy, where he became an industrialist. Coriolis was naturally drawn to the Napoleonic École Polytechnique, a training ground for civil servants, and was second in the class entering in 1808. He spent several years in the department of Meurtheet-Moselle and in the Vosges mountains while in active service with the corps of engineers of the Ponts et Chaussées. His already poor health and the need to provide for his family after his father's death led him to accept in 1816 the duties of tutor in analysis at the École Polytechnique on the recommendation of Cauchy, with whom he shared certain political and religious affinities. From then on, his life was dedicated to the teaching of science; it is this teaching that inspired his work.

In 1829 Coriolis assumed the chair of mechanics at the newly founded École Centrale des Arts et Manufactures; but in 1830, unwilling to assume further duties at the École Polytechnique, he declined the position left vacant by Cauchy's exile. Coriolis had at that time entered into the creative phase of an undertaking that he had developed during the preceding ten years, and he had none too much time to devote to it. However, in 1832 he agreed to assist Navier in applied mechanics at the École des Ponts et Chaussees and succeeded him in 1836. The Academy of Sciences elected him to replace Navier in the mechanics section.

In 1838 Coriolis ended his teaching at the École Polytechnique to become director of studies, a position in which he excelled. His solicitude and attention extended even to working conditions—the water coolers he had installed in the classrooms are still called "Corio's." The unhealthy condition that afflicted him (which also seems to have prevented him from considering marriage) rapidly grew worse during the spring of 1843 and soon overtook him. He was buried in the Montparnasse cemetery on 19 September 1843. Before his death he edited part of the proofs of his last book, which was published the following year.

Coriolis' work is brief and specialized. It belongs to its time, and although it shows no marks of special genius, it was nevertheless innovative. Classical mechanics is indebted to it for fundamental elements necessary to its own complete elaboration.

In 1829 Coriolis published his first book, *Du calcul de l'effet des machines*, begun ten years earlier and inspired by the writings of Lazare Carnot. Coriolis recognized that it was only one item among many others constituting a train of analytical thought addressed to the "economy" of mechanical power, and he modestly declared that his small contribution would be distinctive only in its way of dealing with the subject.

He was right, but his method (formulated while he was teaching at the newly opened École Centrale des Arts et Manufactures) was more important and significant than he was aware. Coriolis was a cultivated man, and for him the word "economy" retained from its Greek etymology a wealth of meaning that was being compromised by the rise of industrialism. While many scientists seemed to favor a radical separation of theory from technology, Coriolis voiced the belief that rational mechanics should be developed as a discipline for the enunciation of general principles applicable to the operation of motors and analysis of the functioning of machinery. The changes in terminology that he proposed, largely as a result of his teaching experience, were in fact conformable to this clearly conceived policy, as they were to the requirements of the theory itself.

The first of these changes consisted in abandoning for the term "force-displacement" the ambiguous designations of mechanical power, quantity of action, and dynamic effect, in all of which was subsumed the consideration that processes occurred in time. The word "work" was in the air following the publication in 1821 of the treatise in which Coulomb had attempted with reference to the limited capacity for activity in men and animals to characterize the notion of the consumption of something in overcoming resistance. The French word—*travail*—conveys the idea particularly well, and it was certainly Coriolis' contribution to assign it a technical meaning and thereby clarify a notion as old as mechanics itself.

Coriolis further proposed the "dynamode" (1,000 kilogram-meters) as a unit of measurement of work (from the Greek *dynamis*, power, and *odos* path). He based this choice upon a comparison of units related to man, the horse, and the steam engine, and hoped thereby to reach a common denominator that might be applied to all industrial functions.

"Dynamode" did not catch on, but the technical term "work" remained the key to a better formalization of mechanics by eliminating once and for all the ambiguities of the famous principle of *vitesse virtuelle* (virtual velocities). The term itself ultimately disappeared.

The second important innovation made by Coriolis was to apply the term *force vive* (kinetic energy) to one-half the product mV^2. This was a simple matter of coefficient but convenient in the formulation of general equations of dynamics. Coriolis thus expressed the principle of *vis viva* as the "principle of the transmission of work." By development of the applications inherent in this change of viewpoint, Coriolis' "small contribution" marked an important step in the realization of his comprehensive theory.

Coriolis did not delay in producing more. Indeed, he had been led to study the work of internal forces in a material system in order to determine under what conditions this work is nil; he thus discovered the very remarkable characteristic that the value of the work done by a system of forces of which the resultant is equal to zero is independent of the frame of reference in respect to which the changes of position are considered. Wishing to evaluate the work done by fluids in hydraulic machines and steam engines, he found simple expressions that apply to the fixed framework of the machine with respect to which the moving parts are in motion. It was therefore natural that the question of relative motions in machines should occur to Coriolis and that it should entail study of the effects of changes in the system of reference on the fundamental equations of analytical mechanics. But he confined himself at first to the simple problem of comparing two systems of reference in rectilinear translation moving uniformly in respect to each other, for which the work done by inertial forces is identical. On 6 June 1831 Coriolis submitted a memoir to the Academy on the problem of the general case. He envisaged it in a highly characteristic fashion; to the extent that consideration of relative motion in machines was unavoidable either to eliminate or to simplify the work of linking forces, theory has necessarily to deal with the question of intertial forces when the system of reference is changed.

Thus for the first time Coriolis entered into the study of acceleration in composite motions, and the various phases of this study's formalization deserve attention.

In his 1831 paper, Coriolis had limited himself to exhibiting the existence of a term complementary to relative acceleration and to acceleration of the drive. Since his explicit aim was to enrich rational mechanics with a new statement concerning the transmission of work in relative motion, he was satisfied to demonstrate by computation—without interpreting the analytical expressions for complementary acceleration—that the work of connecting inertial forces is nil for real relative displacements; the problem of interpreting this result without calculations disappeared in the result itself.

From the two theorems on the transmission of work—one for absolute motion, the other for relative motion—Coriolis easily deduced the difference in the case of hydraulic wheels in the work absorbed by the frame of the machine. He could feel satisfied to have removed certain of the doubts expressed about the possibility of subjecting these machines to theory.

Poisson's report to the Academy did Coriolis the service of observing that the considerations that had animated him should be studied in greater generality. The memoirs that Coriolis submitted to the Academy after 1833 insured this generality in considering material systems as combinations of molecules with various kinds of connections.

The expression for complementary acceleration, derived from the momentum of relative velocity and the instantaneous rotation of the frame of reference, contained in Coriolis'posthumous work, was the enduring fruit of this effort at generality. It was a major advance.

Poisson recognized Coriolis'great skill in the analytic methods deriving from Lagrange. It is true that he did not succeed in eliminating the formidable difficulties inherent in this legacy. Nor did he succeed in determining the conditions under which it is legitimate after a change of variables to employ the expression for live force as a function of the new variable in calculating the work done by inertial forces. It is only nowadays that this is an easy operation to perform, and the restriction in no way detracts from the merit of a pioneer whose problems were still those of applied mechanics.

What is noteworthy, given the generality of his approach, is that those memoirs of Coriolis cited above concern phenomena that arise in practice: collision in the presence of friction and perturbations that disturb the conditions of stability.

The statistical treatment that Coriolis proposed for this last phenomenon (brought to his attention by the steam engine) did not survive the crisis of classical mechanics at the end of the nineteenth century, so that history remembers this eminent polytechnician only for the Coriolis force present in a rotating frame of reference. One application of that force is to fluid masses on the earth's surface. Accordingly, in 1963, a French oceanographic research vessel was named for him, thus honoring the scientist—and not the engineer—in a fitting tribute to a career characterized by its union of theory and technical application.

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II. Secondary Literature. For works on Coriolis, see Jacques Binet, *Discours prononcé aux funérailles de Coriolis le 20 septembre 1843* (Paris, 1843): L.S. Freiman, *Gaspard Gustave Coriolis* (Moscow, 1961), which includes an almost complete bibliography; Nicolas Aimé Renard, *Notice historique sur la vie et les travaux de G. Coriolis* (Nancy, 1861); and Henri Aimé Résal, *Traite de mécanique généale*, **I** (Paris, 1873) pp. 446 ff.

The Secretary's Office at the Archives of the Académie des Sciences possesses a photographic reproduction of Coriolis' portrait.

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