DANIEL D. JOSEPH
1929–2011
Elected in 1990
“For development of ingenious analytical tools and laboratory experiments used in the discovery and elucidation of novel fluid-mechanic phenomena.”
BY KATEPALLI R. SREENIVASAN

DANIEL DONALD JOSEPH, a highly versatile fluid dynamicist, died on May 24, 2011, at the University of Minnesota Hospital. He was Regents Professor Emeritus and Russell J. Penrose Professor Emeritus in the Department of Aerospace Engineering and Mechanics of the University of Minnesota.

He was born on March 26, 1929, in Chicago and followed an unusual path in academics: he earned an MA in sociology from the University of Chicago in 1950 and worked for a few years as a machinist (and an activist sympathizer of the working class). Not getting “enough respect,” he enrolled in engineering at the Illinois Institute of Technology (IIT) in 1957, where he earned a BS in mechanical engineering, an MS in mechanics, and a PhD in mechanical engineering.¹ He started teaching at IIT in 1962 but left to join the University of Minnesota in 1963 soon after earning his doctorate. He retired in 2009 but remained at the university until his demise. His matter-of-factness about the academic job—“it seemed like a good job, the pay was good enough, the prestige was good enough, and

¹Quoted phrases and sentences are Dan Joseph’s own words, most of them from his remarks upon receiving the 1995 Timoshenko Medal of the American Society of Mechanical Engineers.
I liked ideas and I liked to study”—belie the enjoyment he derived and success he attained in academia.

Dan’s interest in fluid dynamics was accidental (as he sometimes said), but the passion he developed was deep and real. He began with a study of fluid flows in geometries with permeable bounding surfaces and ended with considerable interest in small particles that disperse violently upon contact with a liquid surface. As he put it, “My career can…be understood in two phases, the first emphasizing mathematics and the second engineering.” This is a plausible basis for summarizing his work.

Another perspective on his career is evident in his publications. Even as he authored or coauthored more than 400 journal articles, many of them highly original and laden with excellent physical understanding, he often viewed research papers as the prelude for writing books. Each of the seven books he wrote, and the six more he edited, represents a different facet of research that interested him at different points of his career and indicates what he regarded as important.

For the “first phase” of his work, Dan focused on the rich topic of stability of fluid motion. He was a pioneer on the energy theory of stability, and his work in this area led to two highly regarded monographs. Among other topics, they present original work on the global stability and uniqueness of flow through annular ducts, Couette flow between rotating cylinders, spiral Couette-Poiseuille flows, and flow between concentric rotating spheres. He also discussed the global stability of a motionless heterogeneous fluid with constant gradients of temperature and concentration, the variational theory of turbulence applied to convection in porous materials heated from below, stability problems for viscoelastic fluids, and problems of interfacial stability. With Gérard Iooss, he wrote the popular textbook Elementary Stability and Bifurcation Theory (Springer-Verlag, 1980), whose timing was perfect for the development of the subject.

After a decade of immersion in these mathematical problems, Dan directed his attention to the “second phase” of his research, on engineering problems, one of which was the
rheology of viscoelastic fluids with a focus on slow-moving flows. The work did not distance itself from mathematical formulations but made undoubtedly better contact with experiment and data. His book *Fluid Dynamics of Viscoelastic Liquids* (Springer, 1990) develops a tour de force mathematical and physical theory that resulted primarily from the research of his group. A significant discovery was that the unsteady vorticity equation for many models of viscoelastic fluids is hyperbolic, giving rise to waves of vorticity. In steady flows, the vorticity field can be hyperbolic in one place and elliptic in another, as in transonic flows. The key quantity in the discussion of hyperbolic waves of vorticity is the speed of shear waves. Spurred by theory, Dan invented a device in 1986 for measuring the speed of these waves, and followed it up with measurements in a large number of fluids and flows.

His next investigations concerned two-phase fluids, presented in two volumes of *Fundamentals of Two-Fluid Dynamics* (Springer, 1992), coauthored with Yuriko Renardy. A good part of this work concerns the loss of stability of interfaces between phases, an area in which Dan devised a number of elegant experiments to explore physical phenomena and proposed simple explanations for his observations. Another part is concerned with water-lubricated transport of heavy viscous crude oil. The oil travels in a sheath of water along the pipeline, thus reducing the drag and the pumping power, a phenomenon that Dan explained in anthropomorphic terms: “High-viscosity liquids are lazy. Low-viscosity liquids are the victims of the laziness of high-viscosity liquids because they are easy to push around.”

Although Dan himself thought there was some discontinuity of emphasis between the “first” and “second” phases of his work, I expect that history will record them as a continuum: the flow configurations he considered in the “second phase” were often not different from those of the “first.” There was no doubt, however, that he was turning attention increasingly to experiments and to a style and tradition combining them with analysis to extract an essential physical understanding.
In the late 1980s and early 1990s he realized that analytical theory and experiment alone were insufficient to understand the complex phenomena to which he was drawn. He was proud of his decade or so of commitment to the development of computational approaches that could provide details of the particle-level physics of suspension flows. In fact, he led a multi-institution team to develop efficient direct numerical simulation methods and used them to develop models for particles in dense suspensions. He was a true pioneer in this area. His web-based book Interrogations of Direct Numerical Simulation of Solid-Liquid Flows (2002) discusses work in fluidized suspensions in which the inertial effects associated with wakes were identified as important. The “drafting-kissing-tumbling” scenario, corresponding to a rearrangement mechanism by which a sphere interacts with the wake of the preceding one, has now become the standard test case in the validation of direct numerical simulation techniques for particulate flows.

In the last decade of his life Dan worked on viscous irrotational flows, and regarded this work as best suited to his taste—fundamental yet specific. He held the view that, when considering irrotational solutions of the Navier-Stokes equations, it is never necessary, and typically not useful, to put the viscosity to zero; and that, ‘though convenient, phrases such as “inviscid potential flow” or “viscous potential flow” confuse properties of the flow (potential or irrotational) with properties of the material (inviscid or viscous): it is better and more accurate to speak of the irrotational flow of an inviscid or viscous fluid. He was quite disappointed that the rest of the community did not share the same level of enthusiasm for this subject. The results obtained by his group, dispersed in a number of scientific articles, were published in Potential Flows of Viscous and Viscoelastic Fluids (Cambridge University Press, 2007).

In the midst of this extraordinary research life, Dan somehow found time to serve as associate editor of 13 scientific journals, varying in range from the Archives of Rational Mechanics and Analysis to International Journal of Multiphase Flow to SIAM
Journal of Applied Mathematics. Their diversity provides further evidence of Dan’s breadth of interests.

Scholarship did not intrude on his abiding interest in practical matters. He consulted for 13 companies on a variety of problems involving, mostly, multiphase and viscoelastic flows, and held ten patents on tools to address practical problems (e.g., a tensiometer to determine the interfacial tension between immiscible liquids, methods for preventing fouling of pipe walls for lubricated transport, processes for suppressing foam formation in a bubble reactor, and a process for pumping bitumen froth through a pipeline).

In recognition of the impact of his work, Dan was honored in many ways, including membership in both the National Academy of Engineering and National Academy of Sciences, a fellowship of the American Academy of Arts and Sciences, a Guggenheim fellowship, the G.I. Taylor Medal of the Society of Engineering Science, the Timoshenko Medal of the American Society of Mechanical Engineers, the Schlumberger Foundation Award, the Bingham Medal of the Society of Rheology, and the Fluid Dynamics Prize of the American Physical Society, among others.

In summary, Dan was a giant in his field. Three accurate characterizations of him were astuteness, creativity, and hard work. In the preface to Potential Flows, which he wrote with Toshio Funada and Jing Wang, is this statement: “We worked day and night on this research; Funada in his day and our night and Joseph and Wang in their day and his night. The whole effort was a great pleasure.” This work ethic describes Dan to the end. He did not succumb to expensive equipment nor, most of the time, heavy computations. He attributed his success, partly in jest, to his fondness for “low-hanging fruit,” but the statement masks his astuteness in selecting problems that required first-order understanding.

He never let a potential controversy, such as an occasional negative review of an article, interfere with his creativity. More than once he said that one “should take care of [one’s] reputation.” He was a committed jogger for the many years I knew him (“you must take care of your body” was his refrain);
consulted for local and international companies; closely followed the rise and fall of the stock market ("you must take good care of your money"); and did a fair amount of politicking for his students and colleagues. What brought him true pride were the 48 PhD students he supervised ("I owe so much to the string of superb students who have worked with me"). They, in turn, are greatly devoted and loyal to him.

Never one to rest on his laurels, Dan was incessantly pushing himself and those around him to think about new problems. He kept himself young in this way—and, in the minds of many who knew and admired him, he will never die.

He is survived by his wife Kathleen Joseph, sons Charles Joseph and Samuel Guillopé Weissler, daughter Shifra Chana Hendrie, and 13 grandchildren.