



Paul M. Naghdi

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1924-1994

By Ronald P. Nordgren

Paul M. Naghdi, professor of engineering science at the University of California, Berkeley, died on July 9, 1994, at the age of seventy.

Paul was elected to the National Academy of Engineering in 1984 in recognition of his "pioneering contributions to research in continuum mechanics, especially in the areas of shell theory and inelastic behavior of materials." His research encompassed nearly all areas of the mechanical behavior of solids and fluids. He was strongly attracted by fundamental theoretical questions, which he strived to treat at the highest possible level of generality. Paul is best known for his work on the theory of thin elastic shells and the behavior of elastic-plastic materials. In both areas he developed and refined systematic general theories and applied them to significant problems of engineering interest. In his forty-five-year career as an educator, Paul developed a comprehensive series of courses on continuum mechanics, first at the University of Michigan and then at the University of California. At these universities he guided many graduate students in their initial research endeavors. In addition, he was a leader in several professional engineering organizations.

Born on March 29, 1924, in Teheran, Paul Naghdi made a perilous crossing to the United States in 1943 seeking freedom and education. He graduated from Cornell University in

1946 with a B.S. degree in mechanical engineering. Following a brief period of service in the U.S. Army, Paul continued his studies in engineering mechanics at the University of Michigan, earning his M.S. degree in 1948 and his Ph.D. degree in 1951. He was granted U.S. citizenship in 1948.

At Michigan, Paul served as an instructor in engineering mechanics from 1949 to 1951. After graduation he was appointed assistant professor and rose rapidly to the rank of full professor in 1954. In 1958 Paul moved to the University of California, Berkeley, as professor of engineering science. There he led in the establishment of the division of applied mechanics in the Department of Mechanical Engineering and was chairman of this division from 1964 to 1969. In 1991 he was appointed to the Roscoe and Elizabeth Hughes Chair in Mechanical Engineering. In 1994 he advanced to the newly instituted position of professor in the graduate school. As an educator, Paul found the discovery and transmission of knowledge to be very satisfying complementary activities. He was highly devoted to the democratic ideals and processes of the Berkeley faculty and he participated vigorously in academic life.

Paul Naghdi's research interest in the theory of plates and shells was stimulated by a series of summer lectures in 1949 by the legendary applied mechanician Stephen Timoshenko (who immigrated to the United States in 1922). Subsequently Paul developed and refined basic equations for small deformations of thin elastic shells, an effort that culminated in the 1963 publication of a major research article entitled "Foundations of Elastic Shell Theory." During this same period, he and his coworkers also solved a number of static and dynamic shell problems of engineering interest. Continued research on the large deformations of elastic shells led Paul to formulate a strictly two-dimensional nonlinear theory of shells called the Cosserat Surface theory (after the French brothers who originated this idea early in the twentieth century). This approach to shell theory and the classical three-dimensional approach are both contained in Naghdi's definitive article entitled "The Theory of Shells and Plates" in the 1972 *Handbuch der Physik*. Further, Paul extended the

Cosserat surface approach to describe the behavior of fluid sheets and jets. He applied this new theory to solve a number of engineering problems.

The second main thrust of Paul Naghdi's research throughout his career was directed toward characterizing the elastic-plastic deformation of engineering materials. His early research in the 1950s included experiments and solutions to boundary-value problems (with coworkers) as well as contributions to the general theory of small elastic-plastic deformations. Subsequent research in collaboration with his longtime friend A. E. Green led in 1965 to the first systematic theory of elastic-plastic materials undergoing large deformations, published as *A General Theory of an Elastic-Plastic Continuum*. Paul continued to develop and refine this theory and gave a critical review of the subject in 1990. Over the years, he also made important contributions to linear and nonlinear elasticity, viscoelasticity, continuum thermodynamics, and mixture theory. Paul's most recent research focused on the micromechanical aspects of plasticity theory.

Paul Naghdi's educational activities constitute an important contribution to the engineering profession. His comprehensive lecture courses in many areas of the mechanics of continuous media enabled a large number of engineers to gain a fundamental understanding of this subject, at both the graduate and the undergraduate level. These lectures inspired many students to begin research under Paul's guidance and follow productive careers in applied mechanics.

Naghdi was an active member of many professional committees, including the Executive Committee of the American Society of Mechanical Engineers (ASME) Applied Mechanics Division (1967 to 1972; chairman, 1972); the National Research Council, Division of Physical Sciences, U.S. National Committee on Theoretical and Applied Mechanics (1972 to 1984; chairman, 1979 to 1980); the General Assembly of the International Union of Theoretical and Applied Mechanics (1978 to 1984); and the ASME Committee on Honors (1986 to 1994; chairman, 1991 to 1994). In 1977, for the fiftieth anniversary of the ASME Applied Mechanics Division, Paul prepared a comprehensive history of the

division. In April 1994, at great personal hardship, he flew to Denver to chair the last meeting of the ASME Honors Committee under his leadership.

Paul Naghdi received a number of prestigious awards in recognition of his achievements. He was awarded ASME's Timoshenko Medal in 1980 for his fundamental contributions to plasticity and shell theory. This award placed him in the top echelon of engineering scientists of this century. Paul was made an honorary member of the ASME in 1983, and he was elected to the National Academy of Engineering in 1984. Paul received the Eringen Medal of the Society of Engineering Science in 1986. He held honorary doctoral degrees from the National University of Ireland (1987) and the Université Catholique de Louvain (1992). In 1994 he was honored with the Berkeley Citation, the equivalent of an honorary doctoral degree at the University of California. A collection of research papers by his former students and colleagues was published in celebration of Paul's seventieth birthday.¹

Paul Naghdi's activities in research, education, and professional leadership have greatly enhanced the field of applied mechanics in particular and engineering in general. In addition to his specific accomplishments, Paul will be remembered for his inspirational enthusiasm for the research work that so filled his life.

¹ Theoretical, Experimental and Numerical Contributions to the Mechanics of Fluids and Solids," *Special Issue of Journal of Applied Mechanics and Physics (ZAMP)*, J. Casey and M.J. Crochet, eds., 1994. This issue also contains a list of Naghdi's papers (numbering over 200) and an essay on his work.

