of Padua and professor of celestial mechanics at the Scuola Normale Superiore in Pisa. He directed an institute in applied mechanics in Padua and was also a consultant to both the Italian government and the European Space Agency; for many years, he served in a similar capacity at NASA's Jet Propulsion Laboratory.

A native of Padua, he graduated from the University of Pisa in 1943, and, after receiving his PhD in applied mathematics at Padua, he held a succession of academic posts at various universities throughout Italy.

Colombo's early research in nonlinear mechanics gained him international recognition and led, in 1961, to his appointment to the Smithsonian Astrophysical Observatory and, in 1962, to the Harvard College Observatory. Later, he was the Jerome Clark Hunsaker Visiting Professor of Aeronautics and Astronautics at MIT (1980) and the Sherman Fairchild Distinguished Scholar at Caltech (1982).

For nearly a quarter century—indeed, until just a few months before his death—Colombo shuttled regularly between Padua and Cambridge, Pasadena and various other cities in the United States and Europe, where he dispensed advice, wise counsel, and ideas from his apparently unlimited imagination. These usually centered on unlocking the secrets of the solar system and creating spacecraft and space structures to explore it. In 1965, for example, he suggested that Mercury's rotation was in a unique resonance with its orbit, spinning exactly three times on its axis during every two orbital periods. Some years later, while attending a NASA briefing on the Mariner 10 mission, he did a traditional "back of the envelope" calculation showing that the Mariner 10 spacecraft could easily be boosted into an orbit that would bring it back for second and third bonus looks at Mercury, six months apart. These multiple encounters provided, for example, unequivocal evidence that Mercury has an internally-generated magnetic field, contrary to virtually everyone's expectation.

In his heavily accented English, "Bepi," as he was known to his friends here and abroad, would passionately describe new imaginative schemes on each visit on his tour. He held many patents, including one for a new type of "dumbbell" gravity gradiometer. At MIT in 1981, he and his students devised an unusual scheme for delivering large payloads into space orbit, a technique akin to a speeding railroad train snatching up a mail sack. In recent years he devoted much attention to the "skyhook" concept developed in collaboration with Mario Grossi at the Smithsonian Astrophysical Observatory. This idea led to many proposals for applications for tethers extending up to 100 km from satellites in low Earth orbit.

COLOMBO

Even while in the hospital in Italy, Colombo remained in telephone contact with several of his colleagues at the Smithsonian who were developing these ideas with him, including studies of the Earth's upper atmosphere and magnetosphere and of the potential for "skyhook" tethers to generate electric power while knifing through the Earth's magnetic field.

Colombo's contributions were recognized by awards and honors in Europe and the United States. He received Italy's National Award for Astronomy and Geophysics and was elected to the Pontifical Academy of Science; in this country, he received NASA's Gold Medal for Outstanding Scientific Achievement and was a fellow of the American Academy of Arts and Sciences.

Colombo was not only an exciting colleague, but also a loyal friend. It is hard for us to accept a world without him.

GEORGE FIELD
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Harvard–Smithsonian Center for Astrophysics

Nathaniel H. Frank

Nathaniel H. Frank, professor emeritus of physics at MIT, died of a heart attack 19 February 1984. Born in Boston on 18 March, 1903, he was active at MIT from 1919 till his death. He was a student there; then for the last 60 years, he spent his energies and his human sympathies in the teaching of physics. His undergraduate texts are by now classics, and the book on theoretical physics he wrote with John Slater has been standard for many senior courses in the subject. After his "retirement" in 1968, he was active in

the development of instruction in physics for high-school and undergraduate students. His grasp of basic physics, his clarity of exposition and his friendly encouragement have persuaded many students to take up physics as a career. Many, later famous, attest to his inspiration.

His sister writes, "Ned [everyone called him Ned] grew up in a warm, closely-knit family. His father was an office manager, with cultural and intellectual interests; his mother was a remarkable woman, who inspired her children. Ned walked off with every prize at Boston Latin, excelling in mathematics. He entered MIT at 16, younger than most, but he had no trouble coping. At the time his interest was in electro-chemistry; it changed to physics in the next year or so."

Frank served as an assistant in the electrical engineering department for a year after receiving his bachelor's degree; he became a research associate in physics in 1924 and an instructor in physics in 1925. In 1930 Karl Compton came to MIT as its president, recruiting John Slater to be head of the physics department, which they changed from a service department to one supporting research as well as teaching. Frank was one of the previous faculty to stay on; in fact, he was made assistant professor in 1930, after he returned from a year's traveling fellowship in Germany studying under Arthur Sommerfeld. He became associate professor in 1937 and full professor of physics in 1944.

Between 1930 and 1940 Frank was responsible for the reorganization of the two-year introductory course in physics required of all MIT students: He wrote the two texts that were used. During that decade he also took an active part in organizing the senior course in theoretical physics. His lectures on mechanics and on electromagnetics sharpened the minds of several generations of students.

His achievements were not confined to the teaching of physics. He did research under Sommerfeld and, in 1935, as guest at the Princeton Institute for Advanced Study, in electrons in metals. From 1941 to 1943, as a member of the MIT Radiation Laboratory, he studied microwave propagation; and, from 1943 to 1944, he was an expert consultant to the Office of the Secretary of War on radar requirements and operating procedures for the Army and Air Force. In 1949, after returning to MIT, he had to turn his attention to administrative matters, becoming executive officer of the physics department and, from 1952 to 1962, department head.

Thereafter he could return to his first love, the teaching of physics. He participated in the preparation of the

Physical Science Study Committee films on physics, directed the 1965 MIT Study on Occupational, Vocational and Technical Education, and became chairman of the MIT–Harvard Educational Development Center, to implement the study's findings. In 1970 he began his continuing participation in the Experimental Study Group, an academic program for undergraduates at MIT that offers individual instruction in the core subjects through tutorials, seminars and independent study projects. Frank worked closely with this group until five days before his death, tutoring a few students each year and counseling the undergraduate physics tutors.

A few quotations from his colleagues and former students will illuminate Ned Frank's impact on the physics community. David Saxon, now chairman of the MIT Corporation, attributes his becoming a physicist to Frank's influence and describes Frank as a "demanding but sympathetic... teacher." Holly Sweet, associate director of ESG, wrote, "What we will miss the most about Ned is his wonderfully entertaining combination of wit and warmth that inspired us, amused us and occasionally irritated us, but always surrounded us with his care for us." A student, Jonathan Weitsman, describes his first experience with Frank as "very frustrating; no problem had anything called 'the answer.' Ned seemed to see physics problems more as adventures, with more subtleties to be probed. He would always ask, 'What does your answer mean physically?'"

Finally, Peter Dourmashkin, a graduate student in physics at MIT, wrote, "Ned touched many people's hearts and minds, including mine. I will miss him. I'm sure his memory will be an inspiration to me for as long as I teach, as an example of a truly creative and free thinker, unshackled by convention."

PHILIP M. MORSE
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Allen V. Astin

The US lost one of its most distinguished government scientists when Allen V. Astin, former director of the National Bureau of Standards, died of a heart attack 28 January. In a career spanning nearly four decades at NBS, Astin made important contributions to US economic and military security: As a scientist he advanced radio research and led the World War II development of the proximity fuze; as director after the War, he strengthened and broadened NBS programs in many areas of civilian technology.

Perhaps Astin's greatest contributions on behalf of the US technical