

# Founders of Modern Fluid Dynamics

---

## O U T L I N E

Ludwig Prandtl (1875–1953)	869	Supplemental Reading	871
Geoffrey Ingram Taylor (1886–1975)	870		

## LUDWIG PRANDTL (1875–1953)

---

Ludwig Prandtl was born in Freising, Germany, in 1875. He studied mechanical engineering in Munich. For his doctoral thesis he worked on a problem on elasticity under August Föppl, who himself did pioneering work in bringing together applied and theoretical mechanics. Later, Prandtl became Föppl's son-in-law, following the good German academic tradition in those days. In 1901, he became professor of mechanics at the University of Hanover, where he continued his earlier efforts to provide a sound theoretical basis for fluid mechanics. The famous mathematician Felix Klein, who stressed the use of mathematics in engineering education, became interested in Prandtl and enticed him to come to the University of Göttingen. Prandtl was a great admirer of Klein and kept a large portrait of him in his office. He served as professor of applied mechanics at Göttingen from 1904 to 1953; the quiet university town of Göttingen became an international center of aerodynamic research.

In 1904, Prandtl conceived the idea of a boundary layer, which adjoins the surface of a body moving through a fluid, and is perhaps the greatest single discovery in the history of fluid mechanics. He showed that frictional effects in a slightly viscous fluid are confined to a thin layer near the surface of the body; the rest of the flow can be considered inviscid. The idea led to a rational way of simplifying the equations of motion in the different regions of the flow field. Since then the boundary-layer technique has been generalized and has become a most useful tool in many branches of science.

Prandtl's work on wings of finite span (the Prandtl-Lanchester wing theory) elucidated the generation of induced drag. In compressible fluid motions he contributed the Prandtl-Glauert rule of subsonic flow and the Prandtl-Meyer expansion fan in supersonic flow around a corner, and published the first estimate of the thickness of a shock wave. He made notable innovations in the design of wind tunnels and other aerodynamic equipment. His advocacy of monoplanes greatly advanced heavier-than-air aviation. In experimental

fluid mechanics he designed the Pitot-static tube for measuring velocity. In turbulence theory he contributed the mixing length theory.

Prandtl liked to describe himself as a plain mechanical engineer. So naturally he was also interested in solid mechanics; for example, he devised a soap-film analogy for analyzing the torsion stresses of structures with noncircular cross sections. In this respect he was like G. I. Taylor, and his famous student von Karman; all three of them did a considerable amount of work on solid mechanics. Toward the end of his career Prandtl became interested in dynamic meteorology and published a paper generalizing the Ekman spiral for turbulent flows.

Prandtl was endowed with rare vision for understanding physical phenomena. His mastery of mathematical tricks was limited; indeed many of his collaborators were better mathematicians. However, Prandtl had an unusual ability of putting ideas in simple mathematical forms. In 1948, Prandtl published a simple and popular textbook on fluid mechanics, which has been referred to in several places here. His varied interest and simplicity of analysis is evident throughout this book. Prandtl died in Göttingen in 1953.

### GEOFFREY INGRAM TAYLOR (1886–1975)

Geoffrey Ingram Taylor's name almost always includes his initials G. I. in references, and his associates and friends simply refer to him as "G. I." He was born in 1886 in London. He apparently inherited a bent toward mathematics from his mother, who was the daughter of George Boole, the originator of "Boolean algebra." After graduating from the University of Cambridge, Taylor started to work with J. J. Thomson in pure physics.

He soon gave up pure physics and changed his interest to mechanics of fluids and solids. At this time a research position in dynamic meteorology was created at Cambridge and it was awarded to Taylor, although he had no knowledge of meteorology! At the age of 27 he was invited to serve as meteorologist on a British ship that sailed to Newfoundland to investigate the sinking of the *Titanic*. He took the opportunity to make measurements of velocity, temperature, and humidity profiles up to 2000 m by flying kites and releasing balloons from the ship. These were the very first measurements on the turbulent transfers of momentum and heat in the frictional layer of the atmosphere. This activity started his lifelong interest in turbulent flows.

During World War I he was commissioned as a meteorologist by the British Air Force. He learned to fly and became interested in aeronautics. He made the first measurements of the pressure distribution over a wing in full-scale flight. Involvement in aeronautics led him to an analysis of the stress distribution in propeller shafts. This work finally resulted in a fundamental advance in solid mechanics, the "Taylor dislocation theory."

Taylor had an extraordinarily long and productive research career (1909–1972). The amount and versatility of his work can be illustrated by the size and range of his *Collected Works* published in 1954: Volume I contains "Mechanics of Solids" (41 papers, 593 pages); Volume II contains "Meteorology, Oceanography, and Turbulent Flow" (45 papers, 515 pages); Volume III contains "Aerodynamics and the Mechanics of Projectiles and Explosions" (58 papers, 559 pages); and Volume IV contains "Miscellaneous Papers on Mechanics of Fluids" (49 papers, 579 pages). Perhaps G. I. Taylor is best known for his work on turbulence.

When asked, however, what gave him maximum *satisfaction*, Taylor singled out his work on the stability of Couette flow.

Professor George Batchelor, who has encountered many great physicists at Cambridge, described G. I. Taylor as one of the greatest physicists of the century. He combined a remarkable capacity for analytical thought with physical insight by which he knew “how things worked.” He loved to conduct simple experiments, not to gather data to understand a phenomenon, but to demonstrate his theoretical calculations; in most cases he already knew what the experiment would show. Professor Batchelor has stated that Taylor was a thoroughly lovable man who did not suffer from the maladjustment and self-concern that many of today’s institutional scientists seem to suffer (because of pressure!), and this allowed his creative energy to be used to the fullest extent.

He thought of himself as an amateur, and worked for pleasure alone. He did not take up a regular faculty position at Cambridge, had no teaching responsibilities, and did not visit another institution to pursue his research. He never had a secretary or applied for a research grant; the only facility he needed was a one-room laboratory and one technical assistant. He did not “keep up with the literature,” tended to take up problems that were entirely new, and chose to work alone. Instead of mastering tensor notation, electronics, or numerical computations, G. I. Taylor chose to do things his own way, and did them better than anybody else.

## Supplemental Reading

- Batchelor, G. K. (1976). Geoffrey Ingram Taylor, 1886–1975. *Biographical Memoirs of Fellows of the Royal Society*, 22, 565–633
- Batchelor, G. K. (1986). Geoffrey Ingram Taylor, 7 March 1886–27 June 1975. *Journal of Fluid Mechanics*, 173, 1–14
- Oswatitsch, K., & Wieghardt, K. (1987). Ludwig Prandtl and his Kaiser-Wilhelm-Institute. *Annual Review of Fluid Mechanics*, 19, 1–25
- Von Karman, T. (1954). *Aerodynamics*. New York: McGraw-Hill.