Ludwig Prandtl is considered to be the founder of modern fluid mechanics. He, like Newton, Einstein, Galileo and Darwin made fundamental and revolutionary advances in his field of work.

Prandtl was born in Freising, Germany on February 4, 1875. His doctoral thesis was on elastic stability. August Föppl, his thesis advisor, was to later become, following the "good German academic tradition", Prandtl's father-in-law. In 1901 he became Professor of Mechanics at the University of Hanover. The famous mathematician Felix Klein brought Prandtl as Professor of Applied Mechanics to the University of Gottingen in 1904. In 1925, Prandtl became the Director of the Kaiser Wilhelm Institute for Fluid Mechanics. Prandtl stayed in Gottingen until his death on August 15, 1953.

In 1904, at the age of 29, Prandtl proposed the boundary-layer theory, perhaps the most important discovery in fluid mechanics. According to the theory, for fluids with small viscosity, like air and water, viscous effects are confined to the boundary layer, a thin region next to a solid surface; outside the boundary layer the flow is essentially non-viscous. At once he bridged the long standing gap between theoretical 'hydrodynamics' and the practical, but empirical, 'hydraulics'.

Aerodynamic design since then has been routinely done with the boundary layer equations, which are simpler than the full Navier–Stokes equations. Perhaps more importantly, it turns out that the boundary layer concept allows us "to think intelligently about almost any problem in real fluid flow". Related to the boundary layer is boundary-layer separation, a phenomenon that distinguishes streamlined from bluff bodies. Prandtl showed that if the boundary layer on a bluff body becomes turbulent then its drag is reduced. This is why dimples on a golf ball, designed to induce turbulence, give a longer drive! Boundary-layer theory subsequently was put in a rigorous mathematical form and now has spread to other fields of engineering and physics.

Besides boundary-layer theory, Prandtl had other significant contributions. Prandtl and his students showed that transition to turbulence starts with an instability in the flow. It was earlier known that viscosity tends to stabilize a flow. Prandtl showed, however, that viscosity has a dual role and that it also destabilizes some flows. He and Karman gave the famous log-law for turbulent boundary layers. Prandtl's mixing-length theory is the basis of most turbulence models used today. The Prandtl–Lanchester wing theory, proposed independently by Prandtl and F N Lanchester, is used to calculate the flow and the induced drag on wings of finite span; the induced drag is related to the trailing vortices often seen as a pair of white streaks in the sky left behind by an airplane. In high speed flow, he contributed the Prandtl–Glauert rule, the Prandtl–Meyer expansion in supersonic flow around a corner, and also he gave the first estimate for the thickness of a shock wave. Towards the end of his career Prandtl became interested in meteorology. Prandtl worked in solid mechanics as well. He devised a soap-film analogy for analyzing the torsion stresses in structures with non-circular cross-sections.

In experimental fluid mechanics he made notable innovations in the design of wind tunnels and designed the pitot-static tube for measuring velocity. His many flow visualization pictures, that are still reproduced in textbooks, were taken in a simple water tunnel that Prandtl built with his own hands. (See *Figure* 1.)

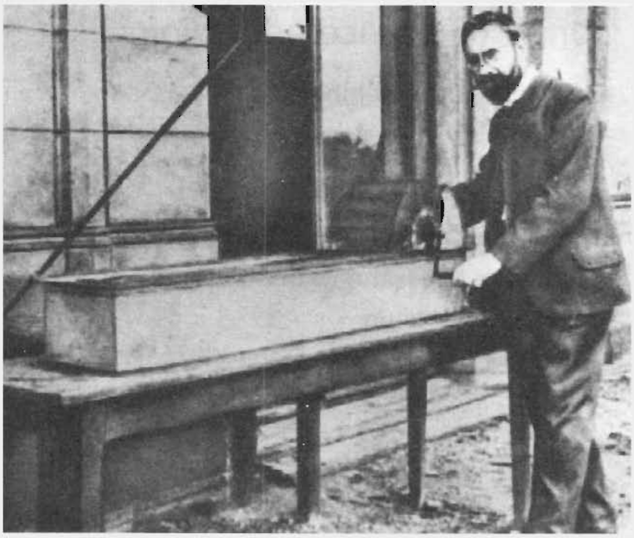

***Figure 1. Ludwig Prandtl beside his water-tunnel at the TU Hannover 1904.** (From: http://gamm2000.dlr.de/Prandtl-Exhibition/wasserkanal.html)*

Prandtl's influence has also been widespread through his association with his students and colleagues, many who are famous in their own right. Prandtl guided over eighty Ph.D students. Students of fluid mechanics will readily recognise some of the scientists who have passed through Gottingen: von Karman, Betz, Tollmien, Tietjens, Ackert, Pohlhausen, Blassius, Munk, Hiemenz. Prandtl has a connection with India: His student Tietjens spent many years in the Aeronautics Department at the Indian Institute of Science, Bangalore. Indeed, "The seeds sown by Prandtl have sprouted in many places, and there are now many second-growth Gottingers who do not even know that they are".

Prandtl has been an influential educator. He took his teaching seriously. After a tour of Japan and the USA he expressed surprise that a professor could teach students straight from a book that someone else had written. However, "He was not a fascinating lecturer, simply because he was often thinking too far ahead". Many teachers of fluid mechanics today still consider Prandtl's *Essentials of Fluid Dynamics* and the two volumes on *Hydro-and Aeromechanics* co-authored with O G Tietjens as the best books in the field. Often one goes back to these books to get fresh insights or if in doubt about some aspect of fluid mechanics.

Prandtl's genius lay in his ability to keep only the essential elements in a physical phenomenon and throw away the rest. His undoubtedly rare physical intuition seems to have developed from simple experiments in the laboratory and a keen observation of phenomenon in everyday life; "on his way home he would explain to his companion the standing waves on the rainwater approaching the gully". As in the case of Einstein, Prandtl's collaborators often surpassed him in mathematical ability. Perhaps this lack of ability was a blessing that kept his mind uncluttered from details of technique and left it free to think about the essential physics.

Despite an extraordinary amount of effort, turbulence, a subject that was close to Prandtl's heart, is still an unsolved problem. Maybe the time is ripe for another Prandtl.

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