# PURDUE FLUIDS SEMINAR SERIES

## A UNIVERSAL VELOCITY PROFILE FOR WALL BOUNDED FLOWS

**FRIDAY NOVEMBER 1ST, 2024**
**SEMINAR 2:15PM-3:00PM ARMS 1010**
**DISCUSSION 3:30PM-4:00PM ARMS 1109**


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Abstract:
Classical mixing length theory is combined with a new mixing length model of the turbulent shear stress to solve the momentum equation for the pipe/channel flow velocity profile. The solution takes the form of an integral that is uniformly valid from the wall to the channel centerline at all Reynolds numbers from zero to infinity. The universal velocity profile (UVP) generated this way can be viewed as a replacement for the classical wall-wake formulation. All 26 profiles of the Princeton Super Pipe data are approximated to within a root mean square error of 0.3%. The UVP also provides a fit of comparable accuracy to channel flow DNS data and to simulated and experimental boundary layer data including zero, favorable and adverse pressure gradient cases. Application of the UVP to rough-wall pipe flow and compressible boundary layers will be discussed. The inherent dependence of the UVP on Reynolds number, extended to include the effect of pressure gradient, enables it to be used as the basis of a new method for integrating the Karman integral boundary layer equation for a wide variety of attached flows. Using this method, the viscous drag of an attached flow airfoil can be rapidly determined at any chord Reynolds number.


Biography
Brian Cantwell is the Edward C. Wells Professor Emeritus in the school of engineering at Stanford University. He received the PhD from Caltech in 1976 and has been a member of the Stanford faculty since 1978 serving as department chairman from 2001 to 2008. His teaching has included courses on aircraft and rocket propulsion, propulsion design, compressible flow, turbulence, similarity methods and experimentation. His research has focused on investigations of the space-time structure of turbulent reacting and non-reacting flows. This work includes studies of the mixing and combustion of an oxidizer flowing over a solid fuel with application to hybrid propulsion systems suitable for high thrust applications, development of a new wastewater treatment method where energy is derived from waste nitrogen and most recently, modeling of wall-bounded turbulent flows. He served as a member and deputy chairman of the AGARD Fluid Dynamics Panel supporting the aerospace technology needs of NATO from 1989 to 1997. From 1994 to 2008 he served as a member of an Executive Independent Review Team overseeing the development of the F119 and F135 engines for the Air Force Raptor and Lighting II fighters. He was given the excellence in teaching award by the Stanford student chapter of the AIAA in 1984 and 1988. He is a Fellow of the American Physical Society, a Fellow of the AIAA, a Fellow of the Royal Aeronautical Society and a member of the National Academy of Engineering. He is the author of four books including a textbook, Introduction to Symmetry Analysis, published by Cambridge Press in 2002.

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