



# 2009 Mechanical Engineering Special Seminar



The Department of Mechanical Engineering is pleased to host



## Pinaki Chakraborty

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**“Turbulent friction on rough and smooth walls:  
it is all in the spectrum (even in 2D)”**

October 27, 2009 | DEWALT Seminar Room, 2164 Glenn Martin Hall | 2:00 pm

**Abstract:** In an arch-famous diagram published in 1933, Johann Nikuradse plotted six log-log curves evincing the dependence on the Reynolds number ( $Re$ ) of the friction coefficient ( $f$ ) of the turbulent flow in six pipes of fixed roughness. (The roughness of a pipe is the ratio  $r/R$ , where  $r$  is the size of the roughness elements that line the interior wall of the pipe, and  $R$  is the radius of the pipe.) Nikuradse’s diagram is rich in distinctive but barely understood features, including a pronounced “hump” where  $f$  peaks shortly after the transition to turbulence; a “smooth regime” governed by Blasius’s empirical scaling,  $f \sim Re^{-1/4}$ ; shallow “bellies” where  $f$  attains local minima at intermediate values of  $Re$ ; and a “rough regime” governed by Strickler’s empirical scaling,  $f \sim (r/R)^{1/3}$ . Here I will derive an expression for  $f$  by assuming that the eddies that transfer momentum between the rough walls and the flow are governed by the phenomenological spectrum of turbulence (Kolmogorov’s spectrum for the inertial range with corrections for the energetic and dissipation ranges). I will show that the resulting expression for  $f$  is in minute qualitative agreement with Nikuradse’s diagram, including all of the distinctive features listed above. I will also describe ongoing experimental work aimed at confirming the existence of close ties between turbulent friction and the turbulent spectrum in 3D flows. Next, I will turn to 2D turbulent flows. I will predict theoretically, for the first time, the dependence of  $f$  on  $Re$  and  $r/R$  for 2D turbulent flows. For the inverse energy cascade, the predictions are the same as for 3D flows. For the enstrophy cascade, I will predict the modified Blasius scaling  $f \sim Re^{-1/2}$  and the modified Strickler scaling  $f \sim r/R$ . To verify these theoretical predictions, I will invoke a set of computational simulations performed recently by Guttenberg and Goldenfeld. I will also describe ongoing experimental work on turbulent friction in 2D flows in soap films.

**Biography:** Pinaki Chakraborty received his Doctor of Philosophy degree in Theoretical and Applied Mechanics from the University of Illinois in 2006. He is currently a research scientist in, the Geological Fluid Dynamics group headed by Prof. Susan Kieffer, University of Illinois. His research interests span a broad range of topics: fluid dynamics (interfacial, multiphase, geological, atmospheric), turbulence, foam mechanics, granular flows, and thermal physics.

For more information, please visit: [www.enme.umd.edu](http://www.enme.umd.edu)

Dr. Chakraborty will be hosted by Professor Jim Duncan of Mechanical Engineering