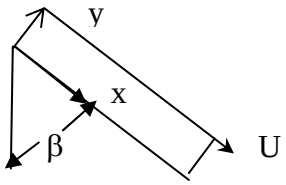
SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
DEPARTMENT OF MATERIALS & METALLURGICAL ENGINEERING

OPEN BOOK

MET 422 HQ 1 Oct 1, 2004

1. Derive an equation for fully developed laminar and Newtonian fluid flow between two parallel plates on an incline having an angle β from the vertical as shown below. Assume the bottom plate is stationary and the top plate has a velocity U down the plate. The plates are separated by a distance of δ.



2 Start with the General Momentum Equation in Cylindrical Coordinates and reduce the equation to the differential equation for flow in a cylindrical tube. Assume there is no flow in the radial or angular directions. Use velocity rather than momentum terms and assume the fluid is incompressible (i.e. – constant density).

3. Consider the SDSM&T flagpole. To find the load at the base of the pole on a windy day, one must know the force exerted on it by the wind. Compute the force for each meter-long segment, assuming there are no end effects, that it is 10 cm in diameter, and that the wind is blowing at 44 m/s. Assume the atmospheric pressure is 0.95 atm and the temperature is 280 K. R=0.08205 L*atm/(gmole*K) and the molecular weight of air is 28.8. The Pr# for air is 0.7.

4 One of your classmates suggested that it would be fun to model a hurricane hitting palm trees. The idea was that the class could set up a variable speed fan and make $1/20^{th}$ of actual size scale models of palm trees and then film their gyrations. Once filmed, the real event could be mimicked by playing back the video providing, of course, it was slowed down or up just right.

Flexure of the palms depends on Young's Modulus ([=]Newtons/m^2 [=] Kg/(m*s)) and the forces exerted by the wind, which depend on the air's ρ, η, V_∞ , and some characteristic dimension, say D. For the time being, it is decided to skip the effect of gravity on the swaying motion of the palms, because it is likely to be a secondary effect compared to the effect of the gale force winds. Assume that the above five independent variables determine everything about the movement of the palms.

a) How many independent, dimensionless groups would be needed to model this situation?
b) If air is also used for the small model, what might you change, to make the models behave in a similar fashion?
c) Do you think you are able to predetermine that the model is $1/20^{th}$ scale or must that remain something computed so as to make the model work and why?
d) Suggest how would one compute just how much to speed up (or slow down) the video to make everything look realistic?