Problem 109E

When a vehicle such as an automobile slams on its brakes (locking the wheels) on a very wet road it can "hydro-plane". In these circumstances a film of water is created between the tires and the road. Theoretically a vehicle could slide a very long way under these conditions though in practice the film is destroyed before such distances are achieved (indeed tire treads are designed to prevent the persistence of such films).

To analyse this situation consider a vehicle of mass, m, sliding over a horizontal plane covered with a film of liquid of viscosity, μ. Let the area of the film under all four tires be A and the film thickness (assumed uniform) be h. If the velocity of the vehicle at some instant is u find the force slowing the vehicle down in terms of A, u, h and μ. Find the distance, L, it would slide before coming to rest assuming that A and h remain constant (this is not, of course, very realistic). What is this distance for a 1000 kg vehicle if $A = 0.1\ m$, $h = 0.1\ mm$, $u = 10\ m/s$ and the water viscosity is 0.001 $kg/m\ s$?