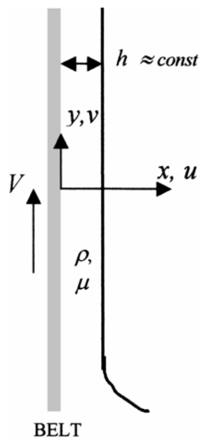
	2nd Mid-Term Exam	**Time: 50 min**
	Course: <u>58:160</u>, *Fall 2007*	
Name:------------------------		**I.D. :**------------

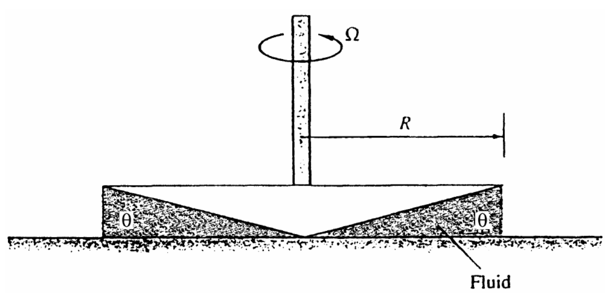
1) A belt moves upward at velocity V, dragging a film of viscous liquid of thickness h, as shown in the figure. Near the belt, the film moves upward due to no-slip. At its outer edge, the film moves downward due to gravity. Assuming that the only nonzero velocity is $v(x)$, with zero shear stress at the outer film edge, derive a formula for (a) $v(x)$; (b) the average velocity V_{avg} in the film; and (c) the wall velocity V_c for which there is no net flow either up or down.

(30)



2) The torque M required turning the cone-plate viscometer in figure below depends upon the radius R, rotation rate Ω, fluid viscosity μ, and cone angle θ. Rewrite this relation in dimensionless form. How does the relation simplify if it is known that M is proportional to θ?

(30)



3) The power P generated by a certain windmill design depends upon its diameter D, the air density ρ, the wind velocity V, the rotation rate Ω, and the number of blades n. (a) Write this relationship in dimensionless form. A model windmill, of diameter 50 cm, develops 2.7 kW at sea level (ρ =1.2255 kg/m^3) when V = 40 m/s and when rotating at 4800 rev/min. (b) What power will be developed by a geometrically and dynamically similar prototype, of diameter 5 m, in winds of 12 m/s at 2000 m standard altitude (ρ =1.0067 kg/m^3)? (c) What is the appropriate rotation rate of the prototype? ***(Hint:** use ρ, D and V as repeating variables)*

(30)