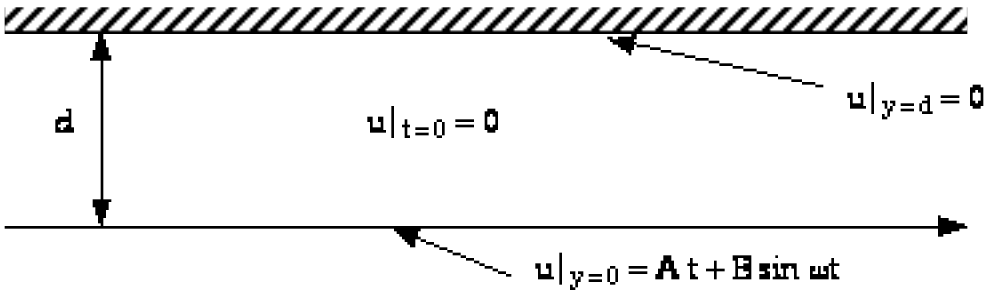
CHEG 544 Transport Phenomena I
First Hour Exam

Closed Books and Notes

1). (15 points) A sphere is freely suspended (e.g., no forces or torques are exerted on it) in an infinite fluid undergoing the linear shear flow $u_i = A_{ij} x_j$ at zero Reynolds number. Determine the most general relationship for the sphere's angular velocity Ω_i as a function of the rate of strain tensor A_{ij}. Using this, prove that the angular velocity of a sphere suspended in any pure straining flow (e.g., a symmetric rate of strain tensor $A_{ij} = A_{ji}$) is zero.

2). It is proposed that the stress-strain relationship of a fluid be probed using a Couette viscometer where the imposed velocity of the lower plate is a combination of a linear ramp in velocity and an oscillatory velocity. The resulting problem is depicted below:



we wish to examine the influence of fluid inertia on the stress measured at the lower plate.

a). (15 points) What is the stress at the lower plate at large times? You may leave your answer in terms of complex variables.

b). (15 points) How long will we have to wait before the solution obtained in part (a) becomes valid? (Hint: Determine the leading eigenvalue.)

3). (15 points) A plate bounding a fluid initially at rest is impulsively started with a velocity given by $u|_{y=0} = U_0 + A\,t$ as is depicted below. Determine the shear stress at the wall to within two unknown numerical constants, and show how these may be calculated from simple ODE's. (Hint: Think linearity and break up the problem!)