Homework 3 MIA503E Due: April 17, 2018

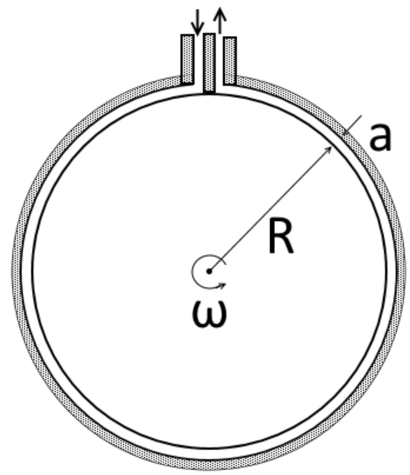
1) Blasius solution to the laminar boundary layer equations yields

$$v = \frac{1}{2}\sqrt{\frac{\nu U_\infty}{x}}(\eta f' - f)$$

For the vertical velocity where the stream function $\psi = f(\eta)\sqrt{\nu x U_\infty}$ and $\eta = y\sqrt{\frac{U_\infty}{x\nu}}$

   a) Verify the expression for v
   b) Find the x component of the acceleration a_x in terms of $f, x\ and\ U_\infty$
   c) Find the expression for the wall shear stress in terms of f and η
   d) Find an algebraic expression for the total viscous drag for a flat plate of length L and width w

2) Consider a viscous shear pump made from a stationary housing with a close-fitting rotating drum inside. The clearance $\boldsymbol{a}$ is small compared to the radius $\boldsymbol{R}$ so that flow in the annular space may be treated as flow between parallel plates.
   a) Find the pressure differential Δp
   b) Input power P_{in}
   c) Power output P_{out} and efficiency P_{out}/P_{in}
   As functions of volumetric flow rate per unit length (Q/b where b is the length of the drum)



3) A spherical particle, under the influence of gravity, falls very slowly through a viscous fluid.
   a) Find the terminal velocity of the particle in terms of $\rho_{\text{particle}}, \rho_{\text{fluid}}, D\ and\ \mu$.
   b) Calculate the velocity for the given values below and check the validity of your assumptions

$$\rho_{\text{particle}} = 4000\frac{\text{kg}}{\text{m}^3}, \quad \rho_{\text{fluid}} = 800\frac{\text{kg}}{\text{m}^3}, \quad D = 0.5\ mm, \quad \mu = 0.1\frac{kg}{m.s}$$