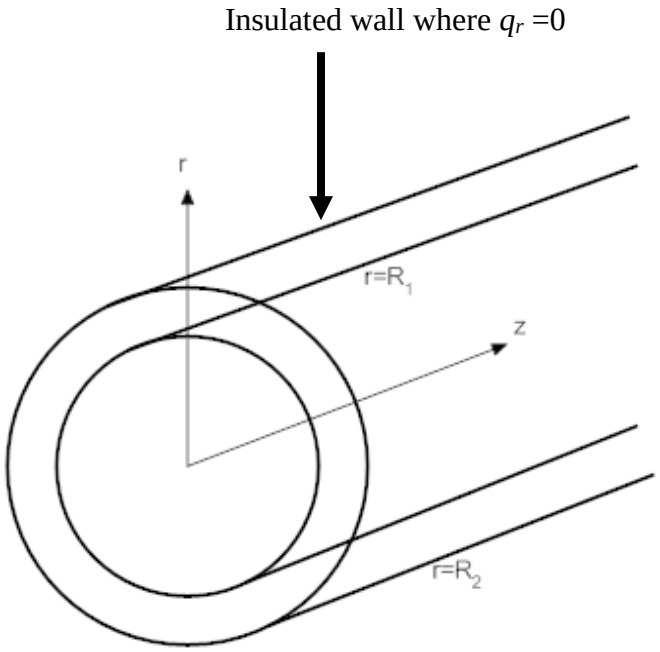
Chemical Engineering Analysis 1

ChE 735 **Elementary Flow Problem** **Fall 2019**

Heating a liquid flowing through an annulus
Due: December 6, 2019

We are going to examine heat transfer in an annulus where the inner surface (at $r=R_1$) is heated and the outer surface ($r=R_2$) is insulated. Flow occurs in the z-direction in the gap between the two walls. The geometry is illustrated in the drawing below.



The governing equation is:

$$\rho C_p V_z \frac{\partial T}{\partial z} = k\left[\frac{\partial^2 T}{\partial r^2} + \frac{1}{r}\frac{\partial T}{\partial r}\right].$$

Since the product, *RePr* is much greater than 100, we do not have to consider conduction in the axial direction. The parametric values we will use are:

R_1=3 cm R_2=5 cm α=0.01 cm^2/s T_1=100°

The liquid enters the heated section with a uniform temperature of 0°. We want to look at two cases: One in which we have *plug flow* at a fixed velocity of 5 cm/s, and the other where no-slip conditions are enforced at the boundaries and the *maximum velocity* in the annulus is 5 cm/s. For both cases we want to know the z-position(s) at which the bulk (average) fluid temperature attains the values 10°, 20°, and 30°.