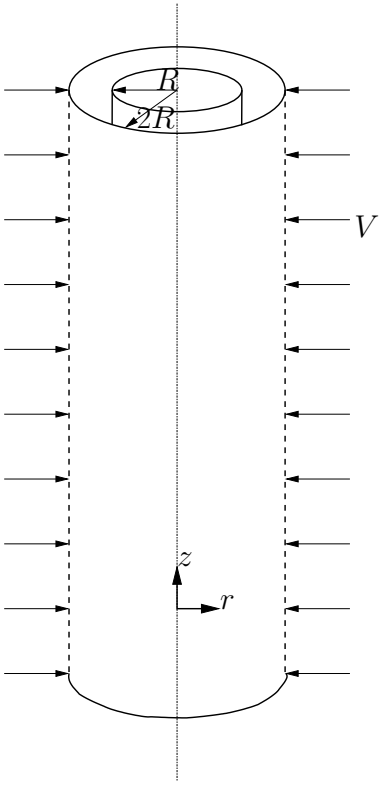
ESCUELA POLITÉCNICA SUPERIOR

INTRODUCTION TO FLUID MECHANICS. **19-12-2016**
PROBLEM 1 (10 POINTS). **Time: 50 minutes**

NAME:..... **GROUP:.....**

Consider the flow induced by a longitudinal pressure gradient $P_l = -\partial P/\partial z \neq 0$ in the cavity between two porous cylinders, as sketeched in the figure. We are interested in analyzing the existence of steady, axisymmetric solutions independent of z. If the liquid is injected, perpendicular to the axis, through the outer wall, with a velocity V,

1. Find the value of the extraction velocity at the inner wall V_i, that allows the existence of a solution independent of z
2. Use, in sequence, the radial momentum equation and the axial momentum equations to find the general form of the reduced pressure field $P(r, z, \theta)$
3. Find the velocity field (v_r, v_θ, v_z), in terms of the Reynolds number defined as $Re = \rho V R/\mu$.
4. Obtain an appropriate expression for the net force exerted by both walls on the liquid.
5. If the temperatures of the outer and inner cylinders are T_{2R} and T_R, respectively, find the temperature distribution $T(r)$. Neglect the viscous dissipation.

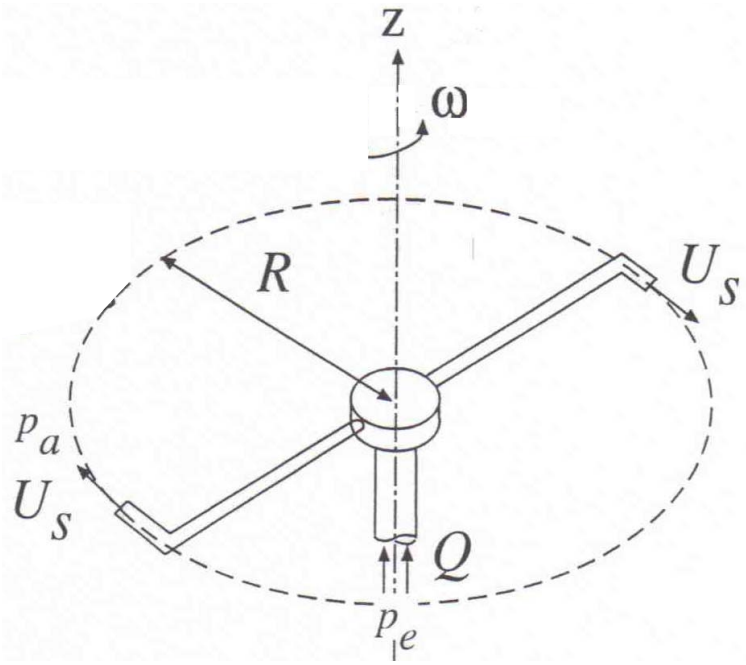


ESCUELA POLITÉCNICA SUPERIOR

INTRODUCTION TO FLUID MECHANICS. **19-12-2016**
PROBLEM 2 (10 POINTS). **Time: 50 minutes**

NAME:..... **GROUP:.....**

Consider the sprinkler shown in the figure. A known flow rate Q enters the system, at pressure p_e , through the entrance pipe, of cross-section area A. The discharge occurs in the atmosphere, at pressure p_a, through two symmetrical pipes of cross section A_s, and length R. As the liquid passes by the system, a torque is generated that makes the sprinkler rotate at a constant angular velocity ω. Not defining **clearly** a reference system and a control volume, to be used in the analysis to follow will produce a penalty of **2 points**.



1. Find the velocity U_s, relative to the sprinkler, of the fluid at the exit.
2. Find the total force exerted on the sprinkler. In the air, neglect viscous forces and consider the pressure variations to be negligible compared to the atmospherc pressure p_a. Indicate, all terms that are cancelled in the equations and –telegraphycally– the reasons.
3. Asssuming ω to be known, find the torque exerted by the fluid on the sprinkler. In the steady movement of the sprinkler, this torque is balanced by the friction in the rotating axis.

In the following, assume the friction torque at the bearing is negligible

4. Obtain the angular velocity of the sprinkler ω
5. If the angular inertia of the sprinkler is I, find the evolution of the angular velocity ω, as a function of time. Modify, in the above analysis, what is needed.

Note: The use of a fixed (inertial) reference system is suggested.