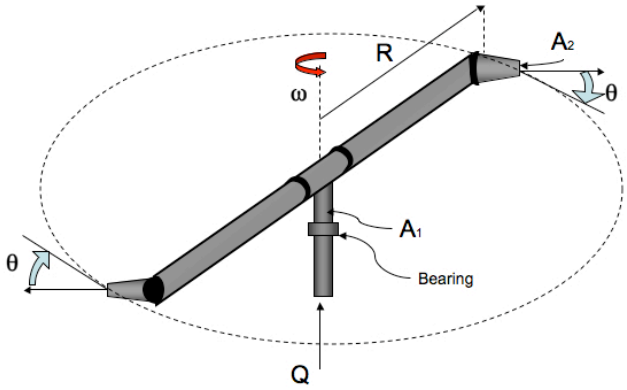
MIT Department of Mechanical Engineering
2.25 Advanced Fluid Mechanics

Problem 5.29
This problem is from "Advanced Fluid Mechanics Problems" by A.H. Shapiro and A.A. Sonin



The sketch shows a lawn sprinkler with two horizontal arms of radial length R, at the termination of which are nozzles (exit Area A_2) pointing in a direction which is at an angle θ relative to the tangent of a circumferential line, as shown. The sprinkler is free to rotate, but the bearing on which it is mounted exerts s torque $k\omega$ in the direction opposing the rotation, ω being the angular rate of rotation. A constant volume flow rate Q passes through the sprinkler, the flow being incompressible at density ρ.

- (a) Find an expression for the steady-state angular velocity ω of sprinkler in terms of the given quantities R, A_2, θ, Q, ρ, and k.
- (b) In the steady state, what is the velocity vector of the fluid emerging from the nozzles, as seen by an observer in the non-rotating reference frame? What is the fluid velocity at the nozzle vent if the bearing is frictionless ($k = 0$)?
- (c) If the pipe area at station 1 near the bearing is A_1, and the flow from that point to the nozzles is inviscid, what gage pressure is required at station 1 to sustain the flow rate in this steady state?

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