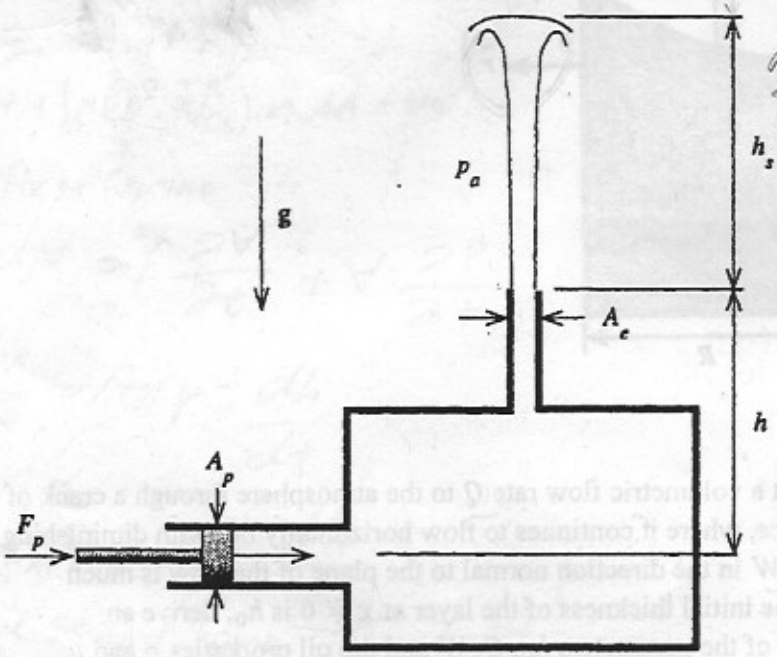
ME721 Fundamentals of Fluid Flow Name: [redacted]

Please include all the intermediate steps in your answers. No score will be given to an answer without justification.

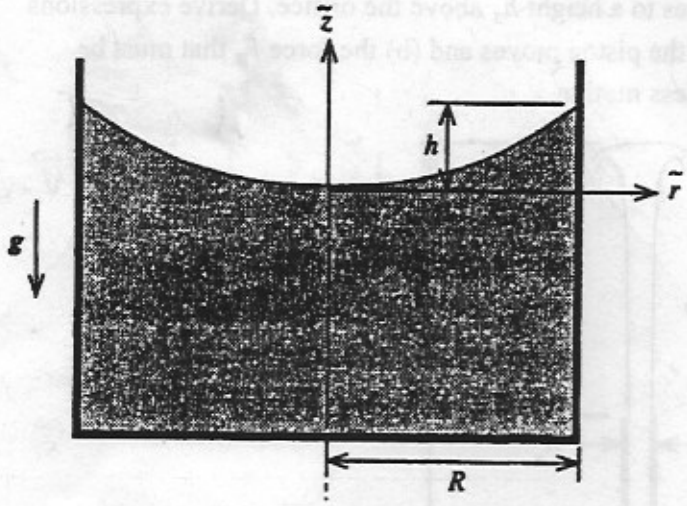
1. (20 points) A container filled with water has an upward-facing orifice of area A_e through which a steady stream of water, propelled by the inward motion of a piston inside a tube of area A_p that is connected to the container, rises to a height h_s above the orifice. Derive expressions for (a) the constant velocity V_p at which the piston moves and (b) the force F_p that must be exerted on the piston, assuming frictionless motion.

$$\frac{d}{dt}=\int_{CV}\rho\, d\forall+\int_{CS}\rho(\vec{V}-\vec{V}_{CS})\vec{n}\, dA=0$$



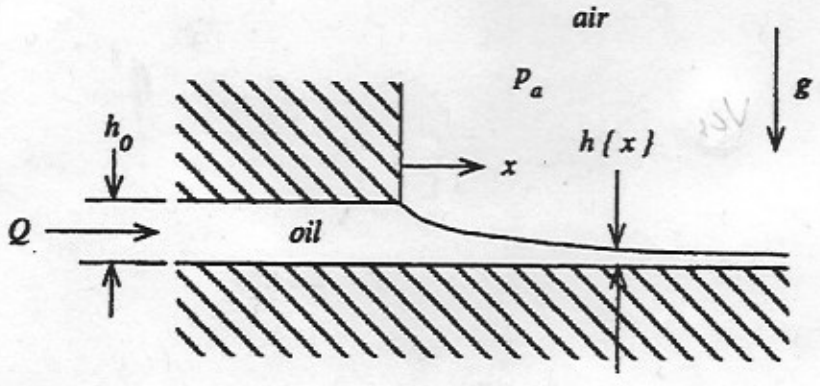
10 2. (30 points) A cylindrical jar of radius R is placed on a record turntable, which revolves at an angular velocity Ω. As shown below, the water level at the outside edge is higher than that at the centerline by an amount h. Using the Euler equation, derive an expression for h.

(*) Do not use the fluid statics approach that we previous used. No score will be given.



20 3. (50 points) Viscous oil leaks at a volumetric flow rate Q to the atmosphere through a crack of height h_0 onto a horizontal surface, where it continues to flow horizontally but with diminishing thickness $h\{x\}$. The crack width W in the direction normal to the plane of the flow is much greater than h_0. Assuming that the initial thickness of the layer at $x = 0$ is h_0, derive an expression for $h\{x\}$ as a function of the parameters h_0, Q, W and the oil properties ρ and μ.

(Hint) The pressure within the film is not constant, although it is constant as p_a at the surface.



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