The steady sink flow in the sketch is set up by injecting water tangentially through a narrow channel near the periphery and letting it drain through a hole at the center. The vessel has a radius $R$. At the point of injection, the water has a velocity $V$ and depth $h_0$; the width of the injection channel, $b$, is small compared with $R$.

In what follows, we consider the region of the flow act too close to the drain, and assume that everywhere in the region (i) the flow is essentially incompressible and inviscid, (ii) the radial velocity component $|v_r|$ is small compared with the circumferential velocity component $v_\theta$, and at the periphery.

(a) Show, by applying the angular momentum theorem to a control volume comprising the water between $r = r$ and $r = R$, that

$$v_\theta = VR/r$$

(b) Show that the assumption $|v_r| \ll v_\theta$ is satisfied if $b \ll R$. 

Problem 5.32
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