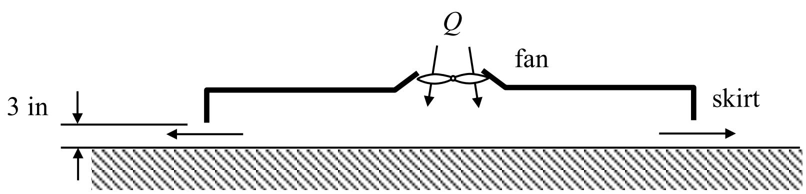
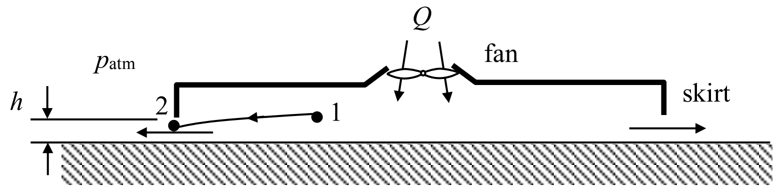
An air cushion vehicle is supported by forcing air into the chamber created by a skirt around the periphery of the vehicle as shown. The air escapes through the 3 in. clearance between the lower end of the skirt and the ground (or water). Assume the vehicle weighs 10,000 lb_f and is essentially rectangular in shape, 30 by 50 ft. The volume of the chamber is large enough so that the kinetic energy of the air within the chamber is negligible. Determine the flowrate, *Q*, needed to support the vehicle.



SOLUTION:

The weight of the vehicle is supported by the increased pressure within the chamber.



A simple force balance gives:

$$W = \left(p_1 - p_{\text{atm}}\right) A_{\text{projected}} \tag{1}$$

Note that we have neglected the downward momentum flux of the air caused by the fan since it will be negligible when compared to the weight of the vehicle.

The pressure within the chamber, p_1, can be found using Bernoulli's equation applied along the streamline shown in the previous figure.

$$\left(\frac{p}{\rho g} + \frac{V^2}{2g} + z\right)_2 = \left(\frac{p}{\rho g} + \frac{V^2}{2g} + z\right)_1 \tag{2}$$

where

$p_2 = p_{\text{atm}}$ $\quad p_1 = ?$

$V_2 = \dfrac{Q}{A_{\text{skirt}}}$ $\quad V_1 \approx 0$ (large chamber)

$z_2 \approx z_1$ (Elevation differences are negligible, especially since a gas is being considered.)

Substitute and simplify.

$$p_1 - p_{\text{atm}} = \tfrac{1}{2}\rho\left(\frac{Q}{A_{\text{skirt}}}\right)^2 \tag{3}$$

Substitute Eqn. (3) into Eqn. (1) and solve for the flow rate Q.

$$W = \tfrac{1}{2}\rho\left(\frac{Q}{A_{\text{skirt}}}\right)^2 A_{\text{projected}}$$

$$\boxed{Q = \sqrt{\frac{2WA_{\text{skirt}}^2}{\rho A_{\text{projected}}}}} \tag{4}$$

Substitute the given parameters.

W	=	10000 lb_f = 322,000 $\text{lb}_\text{m}\text{ft/s}^2$
A_{skirt}	=	(3 in.)(ft/12 in.)[2(30 ft + 50 ft)] = 40 ft^2 (rectangular cross-section)
ρ	=	7.68e-2 $\text{lb}_\text{m}/\text{ft}^3$
$A_{\text{projected}}$	=	(30 ft)(50 ft) = 1500 ft^2 (rectangular cross-section)
$\Rightarrow$		$\boxed{Q = 2990\ \text{ft}^3/\text{s}}$