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**Fluids - 1**

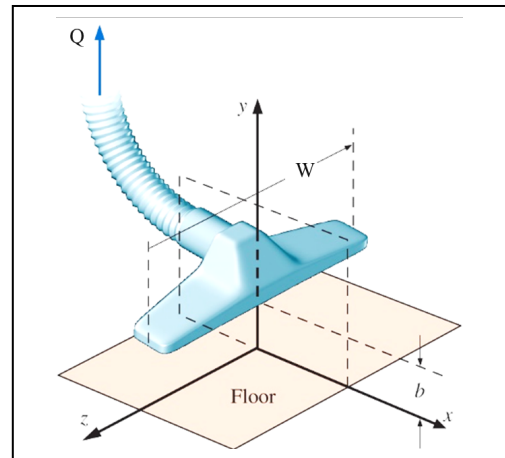

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The flow of air into a vacuum cleaner attachment can be approximated in the centerplane ( $xy$ -plane) as:

$$V_x = \frac{-Qx}{\pi L} \frac{x^2 + y^2 + b^2}{x^4 + 2x^2y^2 + 2x^2b^2 + y^4 - 2y^2b^2 + b^4}$$

$$V_y = \frac{-Qy}{\pi L} \frac{x^2 + y^2 - b^2}{x^4 + 2x^2y^2 + 2x^2b^2 + y^4 - 2y^2b^2 + b^4}$$

where  $b$  is the distance of the attachment above the floor,  $W$  is the length of the attachment, and  $Q$  is the volumetric flowrate of air being drawn into the hose.



- (a) **(20 points)**. Mathematically determine the location of any stagnation point(s) in this flow field. Show your work.
- (b) **(20 points)**. Calculate the air speed along the floor, assuming that the floor can facilitate slip. Dust particles on the floor are most likely to be removed by the vacuum cleaner at the locations of maximum velocity. Where are these location(s)?
- (c) **(60 points)**. For this part of the problem, the vacuum cleaner end attachment is removed. If air enters the 5-cm-diameter and 2-m-long vacuum cleaner hose at 1 atm, 25 °C, and  $Q = 0.11 \text{ m}^3/\text{s}$ , determine the fan power needed to overcome pressure losses in the vacuum cleaner hose. Assuming an overall fan efficiency of 70%, determine the power input to the vacuum cleaner. You may disregard entrance effects, and changes in the potential energy. Take the roughness of the hose to be 0.05 mm and the dynamic viscosity of air to be  $1.85 \times 10^{-5} \text{ Pa}\cdot\text{s}$ . The value for air gas constant is  $R = 0.287 \frac{\text{kJ}}{\text{kg}} \cdot \text{K}$ .